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WAVE DATA MEETING. MEMORANDUM FOR THE RECORD,(U)

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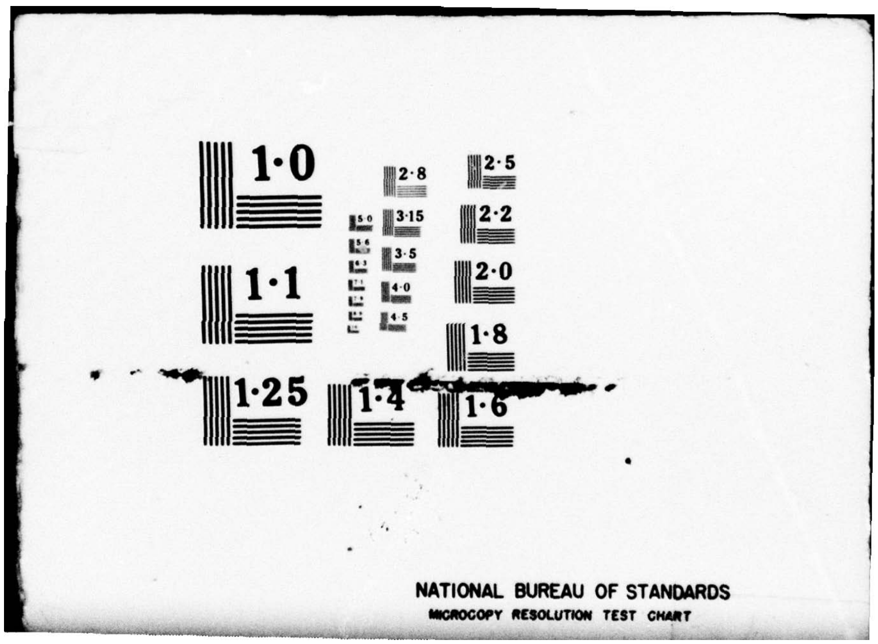
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MEMORANDUM FOR THE RECORD

WAVE DATA MEETING

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ORVILLE T. MAGOON
J. ROBERT EDMISTEN

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South Pacific Div.

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This report provides interim standards for measurement and recording of ocean waves to be used in the proposed California Coastal Data Collection program. This report ~~represents~~ an extension of the proceedings of the international symposium on ocean wave measurement and analysis (B. L. Edge and O. T. Magoon ASCE 1974 Volume 1 & 2) and ~~This report~~ presents rationale used in recommending the interim standards.

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MEMORANDUM FOR THE RECORD
(With 18 Inclosures)

OF

WAVE DATA MEETING
(Including Recommendations For Standards)

At South Pacific Division
Corps of Engineers
San Francisco, California
26-27 October 1977

DEPARTMENT OF THE ARMY
SOUTH PACIFIC DIVISION CORPS OF ENGINEERS
630 SANSOME STREET, ROOM 1216
SAN FRANCISCO, CALIFORNIA 94111

SPDPD-C

23 November 1977

MEMORANDUM FOR THE RECORD:

SUBJECT: Record of 26-27 October 1977 South Pacific Division Coastal Wave Data Meeting Including Recommendations For Standards

1. Subject meeting was held in room 1324 at South Pacific Division Office, 630 Sansome Street, San Francisco, California. Participants are listed in Inclosure 1 and the meeting agenda is presented in Inclosure 2.

2. Inclosures 3 through 15 display pertinent presentations and ancillary materials submissions as indexed in Inclosure 2.

3. Inclosures 16 through 18 contain the recommendations of the sampling, raw data format, and wave measurements philosophy work group, respectively.

4. This Memorandum For The Record with Inclosures will be published and sent for review and comment to an extensive listing of agencies/companies/individuals known to be interested in the measurement and application of coastal wave data.

J. Robert Edmisten

18 Incls
as

J. ROBERT EDMISTEN, P. E.
Coastal Engineering Branch

CF:
SPDPD RF

INCLOSURE 1

COASTAL WAVE DATA MEETING

ATTENDANCE ROSTER (26-27 OCTOBER 1977)

NAME	AGENCY	PHONE NUMBER
Claude Wong	LAD Coastal Res. Br.	FTS 798-5407
Donald G. Spencer	LAD Coastal Res. Br.	FTS 798-5407
Kenneth Steele	NOAA Data Buoy Office	FTS 494-2806
Robert W. Whalin	Waterways Experiment Station	FTS 542-3418, (601) 636-3111 X3418
Don L. Durham	Waterways Experiment Station	FTS 542-3207, (601) 636-3111 X3207
Warren C. Thompson	Naval Postgraduate School	(408) 646-2553/2554
Douglas M. Pirie	SFD Coastal Engineering	(415) 556-5839
Alan Higgins	Scripps Institution	(714) 452-2561
James F. Robinson	South Atlantic Division	FTS 242-4361, (404) 221-4361
R. J. Seymour	Calif. Dept. Navig. & Ocean Dev.	(714) 452-2561
Gary Howell	University of Florida	(904) 392-1436
Wellington Waters	NOAA/EDS/NODC Wash, D. C.	(202) 634-7505
Charles Johnson	North Central Division	FTS (312) 353-6347
Billy L. Edge	Clemson University	(803) 656-3000
D. Lee Harris	CERC	(202) 325-7397, Autovon - 292-7397
Jacob Harari	Corps - SFD	(415) 556-2291
Bob Reynolds	Corps - SFD	(415) 556-5370
Ted Albrecht	Corps - SPDED-H	(415) 556-5709
Clyde Okazaki	Corps - SPD (APD)	(415) 556-0620
Orville Magoon	Corps - SPDPD-C	(415) 556-5352
Bob Edmisten	Corps - SPDPD-C	(415) 556-6390

Incl 1

INCLOSURE 2

AGENDA
COASTAL WAVE DATA MEETING
U. S. ARMY ENGINEER DIVISION, SOUTH PACIFIC
630 SANSOME STREET, ROOM 1324, SAN FRANCISCO, CALIFORNIA
26-27 OCTOBER 1977

26 October		Inclosure Number	
0830	Introductions		Colonel William Vandenberg SPD
0835	OCE Coordination with NOAA	3	Mr. Orville Magoon SPDPD-C
0840	California Coastal Data Program	4	Mr. Bob Edmisten SPDPD-C
0900	DNOD/Scripps/Corps California Data Collection	5	Dr. Richard Seymour DNOD
0930	Coffee		
0945	Wave Direction Measurement for Engineers	6	Mr. Allan Higgins SIO
1015	WES Wave Data Needs	7	Dr. Bob Whalin. WES
1030	WES Wave Measurement & Analysis Technology	8	Dr. Don Durham WES
1100	CERC Wave Measurement & Analysis Technology	9	Dr. D. Lee Harris CERC
1130	Lunch		
1240	East Coast Wave Measurement Problems		Dr. Billy Edge, Clemson University
1300	NOAA's Coastal Wave Monitoring Program (Handout Prepared by Dr. Marshall Earle)	10	Discussion by Mr. Orville Magoon SPDPD-C
1315	NODC Wave Archiving	11	Mr. Wellington Waters NODC
1345	NDBO Programs	12	Mr. Kenneth Steele NDBO
1415	Corps of Engineers Elements Wave Measurement Needs	13	Division/District Representatives
1530	Florida Wave Measuring Network	14	Mr. Gary Howell University of Florida
1600	ASCE Committee on Wave Statistics	15	Mr. Orville Magoon SPDPD-C
1610	Discussion and assignments for work group sessions on 27 October 1977		
1700 - 1900	Social hour (attendance voluntary)		

27 October		Recommendations	
0800 - 1100	Work Group Discussions -	Sampling	(Inclosure) 16
		Raw Data Format	" 17
		Governing Philosophy For Wave Measurements	" 18

Incl 2

INCLOSURE 3

COORDINATION WITH OTHER FEDERAL AGENCIES INCLUDING NOAA

BY ORVILLE T. MAGOON (SPDPD-C)

When General Connell presented the South Pacific Division's California Coastal Data Program at the June 1977 meeting of the Coastal Engineering Research Board (CERB), General Graves stated that planning could start on the West Coast Data Collection System in SPD, and that an examination should be made of the data collection needed by other Corps Divisions. He also indicated that the West Coast (SPD) program should be considered a pilot effort that will provide guidance in carrying out our National Coastal Data Program.

Discussions with personnel from WES, CERC, and other Division Offices indicate that there are no standard wave recording or analysis procedures. In order to follow General Graves guidance, and make our results as applicable as possible throughout the Corps, and if possible, in other Federal Groups, the South Pacific Division is proposing to implement the wave recording and analysis standards and guidelines developed at this meeting subsequent to review and comment by Corps, NOAA, and other interested agencies.

INCLOSURE 4

CALIFORNIA COASTAL DATA PROGRAM PRESENTATION
FOR
26-27 OCTOBER 1977 COASTAL WAVE DATA MEETING
AT
U. S. ARMY ENGINEER DIVISION, SOUTH PACIFIC
SAN FRANCISCO, CALIFORNIA
BY: MR. BOB EDMISTEN

CALIFORNIA COASTAL DATA PROGRAM - INTRODUCTION (1)

The South Pacific Division is in the process of implementing its California Coastal Data Program which consists of two elements: (1) A long-term determination of the wave climate along the entire California Coast; and (2) An extensive, uniform collection of data to identify coastal processes.

WAVE CLIMATE MEASUREMENTS (2)

To fulfill the first element, we propose to implement a three-year wave measurements program at about 100 locations along the coast. This program would use 60 pressure transducers and 40 wave measuring buoys with the necessary telemetry.

LOCATION OF WAVE MEASUREMENTS (3)

This slide gives you some idea of the locations where wave measurements would be obtained. The locations of pressure transducers are shown in red. The wave recording buoy locations are shown in green.

IMPERIAL BEACH PIER (NA)

The 60 pressure transducers would be located on existing fixed structures, such as this pier at Imperial Beach. Data would be transmitted to a central facility by telephone lines.

WAVE RIDER BUOY (NA)

The 40 wave measuring buoys would be located in water depths of about 200 feet or less. This picture of a buoy on station in Canadian waters gives you an idea of what our buoys would look like.

TELEMETRY SCHEMATIC (4)

Data collected by the buoys would be radioed to shore and then sent over telephone lines to the central facility. Data from the pressure transducers would be sent to shore by cable and then similarly sent to the central facility.

OTHER CALIFORNIA WAVE PROGRAMS (5)

We intend to use wave data from other California wave programs.

The State of California's Department of Navigation and Ocean Development (DNOD/SCRIPPS) concur in the need for our program and promise full cooperation. This includes the use of the DNOD wave measurement system now operational at four Southern California sites (Imperial Beach, Ocean Beach, Scripps' Pier and Oceanside).

The U. S. Navy has a maximum of four gages along the California coast. Navy personnel have told us they would welcome our measurements and would make their wave measurement data available to us.

Oil company representatives have indicated there are wave gages on both production and exploratory platforms in Southern California. They have informed us that their data could probably be made available to us and also

that their offshore towers could generally be used for mounting our wave gages.

The National Ocean Survey of NOAA plans to establish deepwater buoys off California in 1980 if funding is obtained.

NOAA BUOY NETWORK (NA)

This slide shows the NOAA's Environmental Buoy Network in the North Pacific Ocean. Note that the buoys are very far offshore. Our shallow water measurements would complement their deepwater data.

After reviewing these existing wave programs, we have structured our program to insure there is no duplication.

WAVE DATA ANALYSIS (6)

All wave data would be permanently stored. This would allow a data base to be established which could be reanalyzed to meet future needs. We propose, as a minimum output, to publish monthly and yearly analyses of the wave data in the form of the following products:

a. Spectral Analysis format
b. Wave Roses (Wave Climate)
c. Maximum wave heights
d. Wave height duration

Of course, we wish to include other data analyses output formats which are determined to be required.

The California Coastal Data Program will provide an essential verification and calibration of the WES wave hindcast studies which are in progress. Other environmental parameters which we may wish to measure at selected sites include currents and winds.

This concludes my discussion of the wave climate portion of the proposed program.

COASTAL PROCESSES (7)

Now I would like to discuss the second element, the coastal processes portion of the California Coastal Data Program. This element would consist of an extensive, uniform collection of California coastal processes data. Beach profiles would be repeatedly surveyed and shoreline changes monitored, in part, by the use of remote sensing imagery. Physiographic reaches would be determined taking into account river sediment contributions. Coastal sediment movements would be studied using petrographic analyses as an extension to the work done at the University of California and Scripps Institution of Oceanography. We would expand our littoral environmental observations (LEO) to include approximately 100 sites in cooperation with local interests. Background reports and ongoing California coastal research by universities and others would be summarized and audited by contract with a university group such as the Water Resources Center Archives at the University of California, Berkeley.

PROGRAM DATA USES (8)

How would the data collected be used?

First, we would use the data to improve the planning of our coastal projects. Second, it would allow for more refined designs while resolving the types of coastal problems which we presently experience. Third, we hope to cut the monetary and energy requirements of our operations and maintenance actions at coastal projects. We think the various outputs from the proposed program would lead to major economies in the O&M program. The determination of specific remedial actions at our projects would be conducted through existing authorities Lastly, the Corps should maintain its technical expertise and ability to provide customer services in dealing with coastal matters.

ESTIMATED COSTS - WAVE CLIMATE ELEMENT (9)

Now, let's discuss program costs. To accomplish the wave climate element of the program, subsequent to system design, we would purchase and install the necessary wave measuring and data anaysis equipments the first year at an estimated cost of $1.5 million, and the data collection phase of the program would take place the following three years with annual costs approximating $1.2 million. We would contract out the wave climate portion of our program.

ESTIMATED COSTS - COASTAL PROCESSES ELEMENT (10)

Estimated annual costs for the coastal processes portion of our program would be $650,000 with annual feature costs as shown. Beach profiles would be done by Districts. Remote sensing imagery would be taken by NASA. The determination of physiographic reaches and sediment movements would be

accomplished largely under contract to various universities. It is expected the compilation of existing data would be made by the Water Resources Center Archives at the University of California, Berkeley.

ESTIMATED COSTS - CALIFORNIA COASTAL DATA PROGRAM (11)

Program total estimated costs of $7.0 million would require yearly funding as shown here.

The Corps of Engineers is seeking first year funding in Fiscal Year 1977 for the California Coastal Data Program.

CALIFORNIA PROGRAM - ENDING (NA)

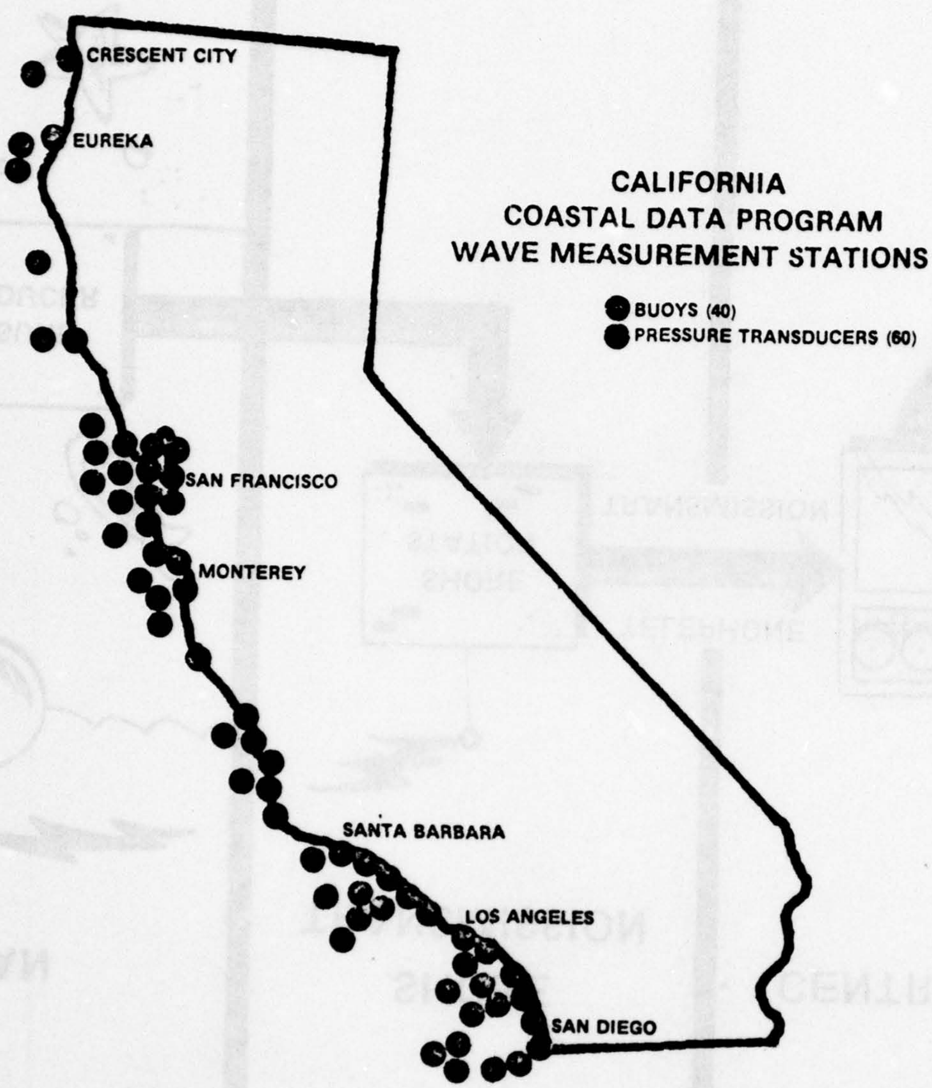
This briefly describes the program we are desirous of implementing at the earliest possible date. We solicit the advice and counsel of others regarding this proposed program to insure maximum benefit from the data which will be obtained.

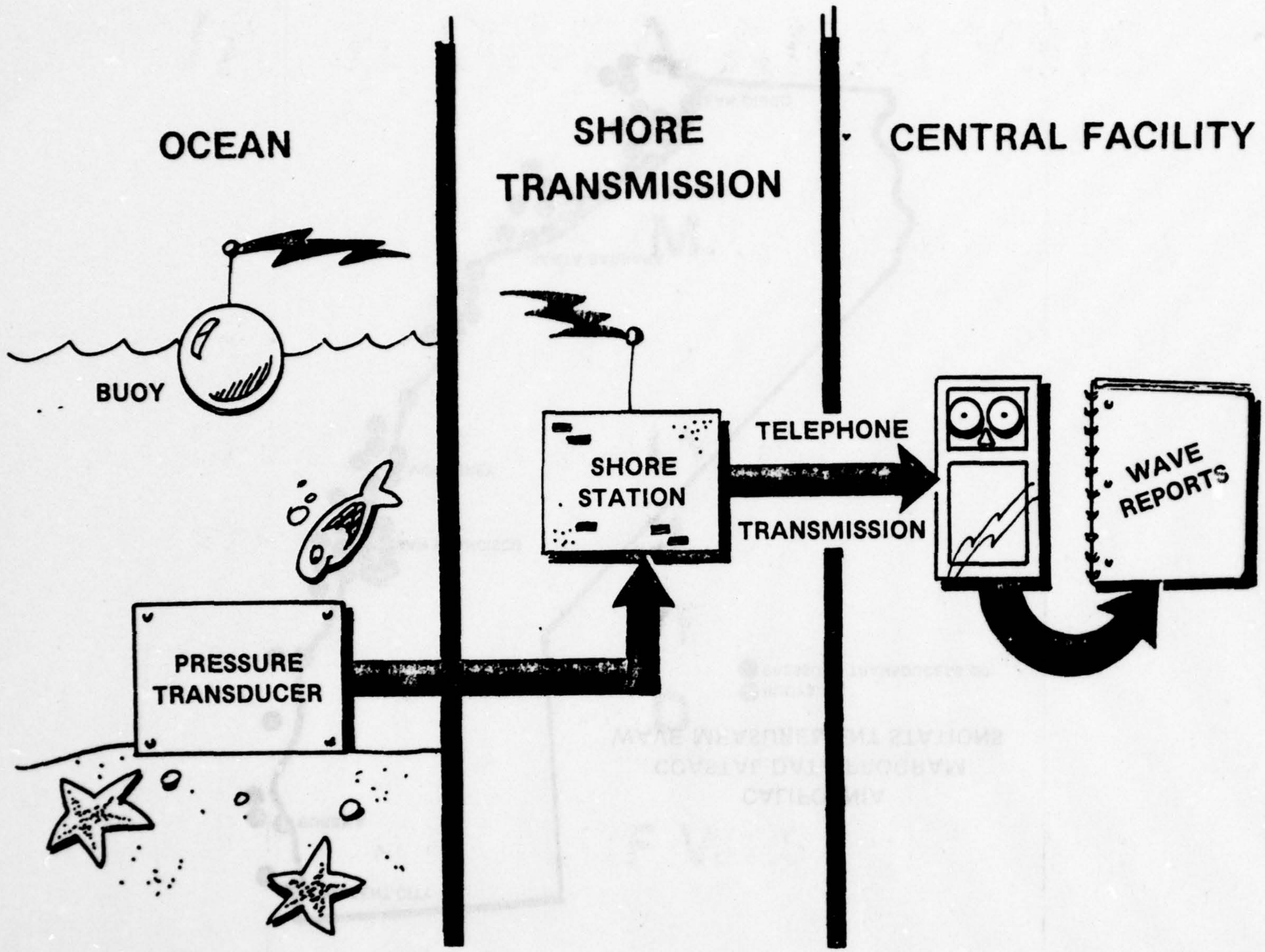
CALIFORNIA COASTAL DATA PROGRAM

- WAVE CLIMATE
- COASTAL PROCESSES

WAVE CLIMATE MEASUREMENTS

- 3 YEARS
- 100 LOCATIONS
  - 60 PRESSURE TRANSDUCERS
  - 40 BUOYS
- TELEMETRY TO CENTRAL LOCATION


CALIFORNIA
COASTAL DATA PROGRAM
WAVE MEASUREMENT STATIONS
BUOYS (40)
PRESSURE TRANSDUCERS (60)
CRESCENT CITY
EUREKA
SAN FRANCISCO
MONTEREY
SANTA BARBARA
LOS ANGELES
SAN DIEGO


OCEAN
SHORE TRANSMISSION
CENTRAL FACILITY
BUOY
SHORE STATION
TELEPHONE
TRANSMISSION
WAVE REPORTS
PRESSURE TRANSDUCER

OTHER CALIFORNIA WAVE PROGRAMS

- DNOD/SCRIPPS
- U.S. NAVY
- OIL COMPANIES
- NOAA

WAVE DATA ANALYSIS

- DATA STORAGE (MAGNETIC TAPE)
- DATA PRODUCTS
  - SPECTRAL ANALYSIS
  - WAVE ROSES (CLIMATE)
  - MAXIMUM WAVE HEIGHTS
  - WAVE HEIGHT DURATIONS
- VERIFICATION OF WES HINDCASTS

COASTAL PROCESSES

- BEACH PROFILES & SHORELINE CHANGES
- PHYSIOGRAPHIC REACHES
- SEDIMENT MOVEMENT
- RELATED STUDIES

PROGRAM DATA USES

- PLANNING
- DESIGN
- OPERATIONS/MAINTENANCE
- CUSTOMER SERVICES

WAVE CLIMATE DATA
ESTIMATED COSTS
($ THOUSANDS)

	PROGRAM YEAR I FIRST COST	PROGRAM YEARS 2-3-4 ANNUAL COST
PRESSURE TRANSDUCERS (60)	$350	$240
BUOYS (40)	1,000	800
INITIAL PLANNING & DESIGN	50	--
CENTRAL FACILITY (DESIGN, CALIBRATION & OPERATION)	100	160
TOTAL	$1,500	$1,200

COASTAL PROCESSES DATA
ESTIMATED ANNUAL COSTS
($THOUSANDS)

• BEACH PROFILES & SHORELINE CHANGES	
1. SURVEYS	$200
2. REMOTE SENSING IMAGERY	60
• PHYSIOGRAPHIC REACH DETERMINATIONS	160
• SEDIMENT MOVEMENT (INCLUDING PETROGRAPHIC ANALYSIS & LEO)	200
• RELATED STUDIES (INCLUDING LITERATURE SEARCH AND SUMMARY OF ONGOING RESEARCH)	30
TOTAL	$650

CALIFORNIA
COASTAL DATA PROGRAM
($ MILLIONS)

YEAR	WAVES	COASTAL PROCESSES	TOTAL
1	1.50	—	$1.50
2	1.20	.65	1.85
3	1.20	.65	1.85
4	1.20	.60	1.80
	$5.10	$1.90	$7.00

INCLOSURE 5

MEASURING THE NEARSHORE WAVE CLIMATE: CALIFORNIA EXPERIENCE

Richard J. Seymour
California Department of Navigation
and Ocean Development

INTRODUCTION:

The need for characterizing the nearshore or coastal wave climate follows the experience of more conventional meteorological climate measurement programs: the higher the population density, the more intense the usage of the resource, the greater the penalty for ignorance -- then the greater the need for local detail and accuracy in the climate statistics. California has a coastline roughly as long as the stretch from Massachusetts to Florida. Much of it is heavily developed. The continental shelf has an extremely convoluted bathymetry and much of the state is in the partial shade of a long string of offshore islands. The coastline is predominantly rocky, punctuated by long reaches of sandy beaches in delicate dynamic equilibrium with the waves and currents, and fed by occasionally swiftly flowing rivers which dump sediment directly into the ocean. These factors combine to produce a situation in which there is a pronounced spatial inhomogeneity in the nearshore wave climate and strong political and economic pressures to define it accurately. This has led the State, through its Department of Navigation and Ocean Development (DNOD) to test the feasibility of constructing a coastal wave data network to automatically acquire coastal wave climate statistics by direct measurement.

THE CALIFORNIA WAVE NETWORK:

The system was inaugurated in 1975 by the Scripps Institution of Oceanography (SIO) with overall direction and financial support by DNOD, and with additional funding support by the Sea Grant program during the past year. Five stations are operational. The first station, at Imperial Beach near the Mexican border, has been reporting data since December 1975. Approximately seven more stations will be added during the next six months. Five of these are proposed to be funded by the Corps of Engineers under a cooperative agreement. Each station consists of one or more bottom-resting pressure transducers which are placed at a depth of about 10 meters. This results in their remaining outside the surf zone under all conditions in the present locations. The transducers are hard wired to a terminal on the beach or on a pier head which contains a telephone connection. The station is polled every 10 hours by a central minicomputer at SIO using ordinary dialup telephone lines. The initial installations utilized FM transmission in real time of approximately 17 minutes of data at one hz. Details of the configuration of the data

transmission system are described in Seymour and Sessions (1976). To reduce the telephone toll charges by more than an order of magnitude, the system is now being reconfigured so that the pressure time history will be digitized at the shore terminal continously and the most recent 17 minutes stored in memory. This memory is dumped rapidly over the phone lines when the central computer calls. Multiple channel capability exists at each station so that any other analog signal can be recorded in addition to the wave records.

DATA REPORTING:

Monthly reports are mailed to users within a few days after the end of every month. These reports contain -- for each ten-hour period and for each station -- the time of observation, the significant wave height, the total energy, and an energy spectrum expressed as a percent of the total energy within period bands of approximately two seconds width. In addition, for each station, tables are shown of the maximum significant wave height for each day in the month and of height persistence -- the number of consecutive days that a particular wave height is exceeded.

One of the most useful data displays is illustrated in Figure 1. It shows a pictorial representation of the spectra for a month at each station so that relative energies can be evaluated and the decay of swell following a storm readily observed. Users quickly learn to interpret these graphical presentations in terms of their own needs and thus avoid tedious scanning of the tabular data. As direction measuring stations are routinely operated, representative directions will be reported for each period band using the methodology described below.

The monthly reports are collected for a six-month period and then reissued under a single cover with a progress report for the system covering the same period. The first semi-annual report [Seymour, et al. (1976)] contains details of the system configuration and operation.

WAVE DIRECTION MEASUREMENT:

Although the spread in wave arrival direction in shallow water is much diminished by refraction compared to deep water waves, the need for accuracy in determining direction is much greater in certain important applications. For example, the longshore transport of sediment by oblique waves appears to be roughly proportional to the magnitude of the angle the crests form with the shoreline, for small angles. Thus direction estimation errors of only a few degrees can result in very significant errors in the estimate of transport. In many cases of interest, the approach angles are characteristically only a few degrees, so that small errors can actually result in the improper sign for the transport -- i.e., failure to predict the proper direction.

WAVE ENERGY SPECTRA - MAR. 1977

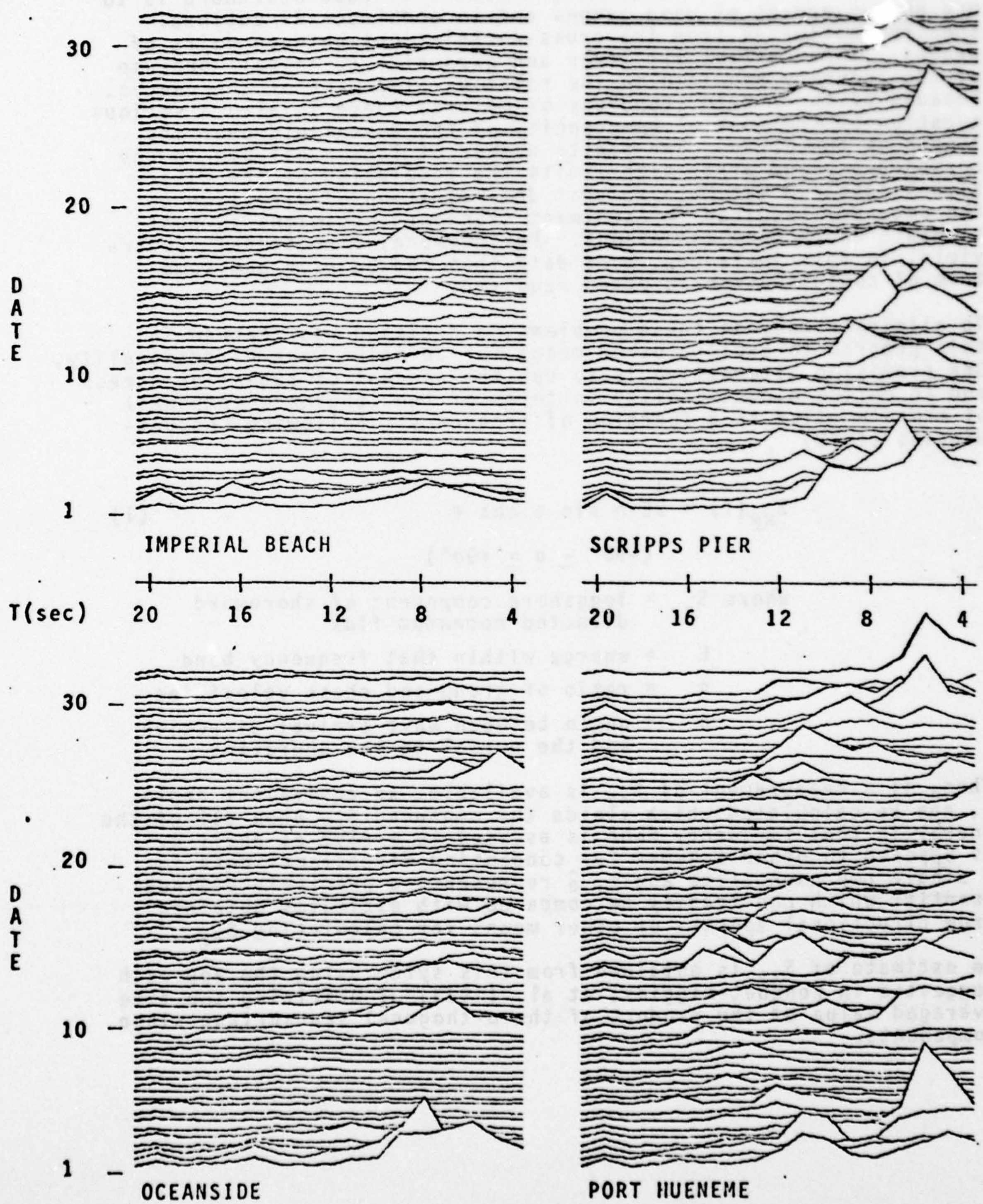


FIGURE 1

The present method for acquiring directional data nearshore is to use phased arrays of wave gauges and to construct directional spectrum estimates from the cross-correlations between pairs of gauges. These arrays are large and expensive to install because of the accuracy required in the relative placement of the gauges. Because of their size (hundreds of meters) there is also a serious question of the spatial homogeneity of the wave field over the length of the array. The finite number of lags available in any reasonable sized array also limits the resolution of the directional spectrum estimate so that determination of direction to the accuracy required for sediment transport estimates is questionable under many conditions. Furthermore, directional spectra yield, in most instances, more data than can be used and some form of consolidation is often required.

To eliminate many of these problems, a decision was reached in this program to explore other means for defining wave directionality. One promising alternative is to use the concept of radiation stress and to define directionality in terms of the longshore component of momentum flux as a function of frequency. Following Longuet-Higgins (1970)

$$S_{xy}(f) = \sum^{\theta} E\, n \sin\theta \cos\theta \qquad (1)$$

$$(-90° \leq \theta \geq +90°)$$

where S_{xy} = longshore component of shoreward directed momentum flux

E = energy within that frequency band

n = ratio of group and phase velocities

θ = angle between wave arrival direction and the normal to the shoreline

Thus, if a measurement of S_{xy} is available, an equivalent angle, $\hat{\theta}$, can be calculated which yields the measured S_{xy} when all of the energy in that frequency band is assumed to arrive at angle $\hat{\theta}$. As opposed to other schemes for condensing directional data to a single representative angle, $\hat{\theta}$ represents a precisely defined quantity which can readily be compared with estimates obtained from directional spectra or other means for calculating S_{xy}.

An estimate of S_{xy} is obtained from this sytem using the approach suggested in Longuet-Higgins, et al. (1963) of utilizing the time averaged value of the product of the orthogonal sea surface slope components.

$$S_{xy}(f) = \frac{n}{k^2} \langle \eta_x \eta_y \rangle \qquad (2)$$

where k = wave number

and $\langle \eta_x \eta_y \rangle$ = time average of slope components

The averaging of the slope components is done in frequency space by substituting the real part of the cross spectrum of the slope component time histories. The slopes are measured by using the difference between the two pairs of bottom-mounted pressure transducers. The fourier coefficients are corrected by standard linear wave theory for the pressure attenuation effects.

A more complete treatment of the theory and a discussion of the magnitude of the errors inherent in this estimation scheme are found in Seymour and Higgins (1977).

Measurement of $\bar{\theta}$ for ocean waves to acceptable engineering accuracy can be made with relatively small arrays -- on the order of six meters on a side. This allows the array to be built into a single rigid frame which needs only angular alignment by divers for installation. This task has been simplified by the development of a diver-operated flux gate compass with accuracy of about a degree over small ranges. Following a suggestion by Professor Robert Dean of the University of Delaware, the use of differential transducers is being explored to allow even further reduction in the array size.

INTERACTIONS WITH DEEP WATER MEASUREMENT PROGRAMS:

Since the principal concern with wave statistics is their application to the nearshore environment, any scheme for producing deepwater statistics -- either using direct measurement or hindcasting techniques -- requires a test of its ability to allow projection into shallow water. Synoptic data from large numbers of nearshore measurement stations provides the ultimate test for any deepwater system. Although inaccuracies or inadequacies in the refraction program will tend to bias the apparent ability of a deepwater measurement or forecast technique to predict wave energy or direction, its usefulness to the coastal engineer depends upon using such refraction analyses and upon being able to predict nevertheless the nearshore wave environment to reasonable accuracy.

If experience with the comparison of nearshore wave climates measured and predicted from deepwater data shows that the deepwater directions cannot be measured or inferred with sufficient accuracy to allow such projections, nearshore measurements can possibly provide a reasonable means for estimating deepwater direction. This approach, advocated for some time by Dean M. P.

O'Brien of Berkeley, is based upon using nearshore wave gauges spaced along a coastline as an array to determine deepwater wave direction. The array could be used in two modes. For a given frequency band, each deepwater wave approach direction can produce a unique fingerprint of spectral intensities at the various elements in the array, provided that the intervening bathymetry is sufficiently irregular to cause nonhomogenous refraction. Thus a central approach direction can, in theory, be deduced by some least squares fitting technique for each frequency band. Note that it is also possible to infer a deepwater energy value by this method, eliminating the need for any deepwater measurements. However, the uncertainties of attenuation mechanisms over the shelf at this point in time would suggest that the most profitable combination might be deepwater energy measurements with a selected nearshore directional array. The second mode of operation would be to use the shore stations as an array which could be considered coherent for events of sufficiently long time scale. Thompson and Smith (1974) shows that swell trains have well defined maxima in group heights that would have phased arrival times measured in hours over an array on the order of a hundred kilometers in length. Again, a best fit technique could be applied to estimate wave direction for well sorted swell.

The present plans, with funding support from the Corps of Engineers, are to construct such an array as a part of the DNOD network around the periphery of Monterey Bay. A total of five or six locations will be employed with an overall gauge length of about 65 km. In addition to the nearshore stations, a surface following buoy will be deployed offshore in a water depth of about 60 m. The telemetry link with this buoy will be connected to a wave network station terminal so that the surface elevation signal from the buoy can be recorded in the same manner used for the shallow water stations. This commonality of equipment offers considerable economies over onboard recording or maintaining individual shore mounted recording systems for each deepwater buoy location.

This nearshore array, coupled with the deepwater buoy data, is scheduled to be in operation prior to the winter storms of 1977-78. It should provide a valuable data set for verification of hindcast models for the North Pacific as well as an opportunity to explore the use of nearshore data for determining deepwater direction.

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1. Seymour, R. J., and Sessions, M. H., "A Regional Network for Coastal Engineering Data," Proceedings of the Fifteenth International Coastal Engineering Conference, ASCE, Honolulu, Hawaii, July 1976.

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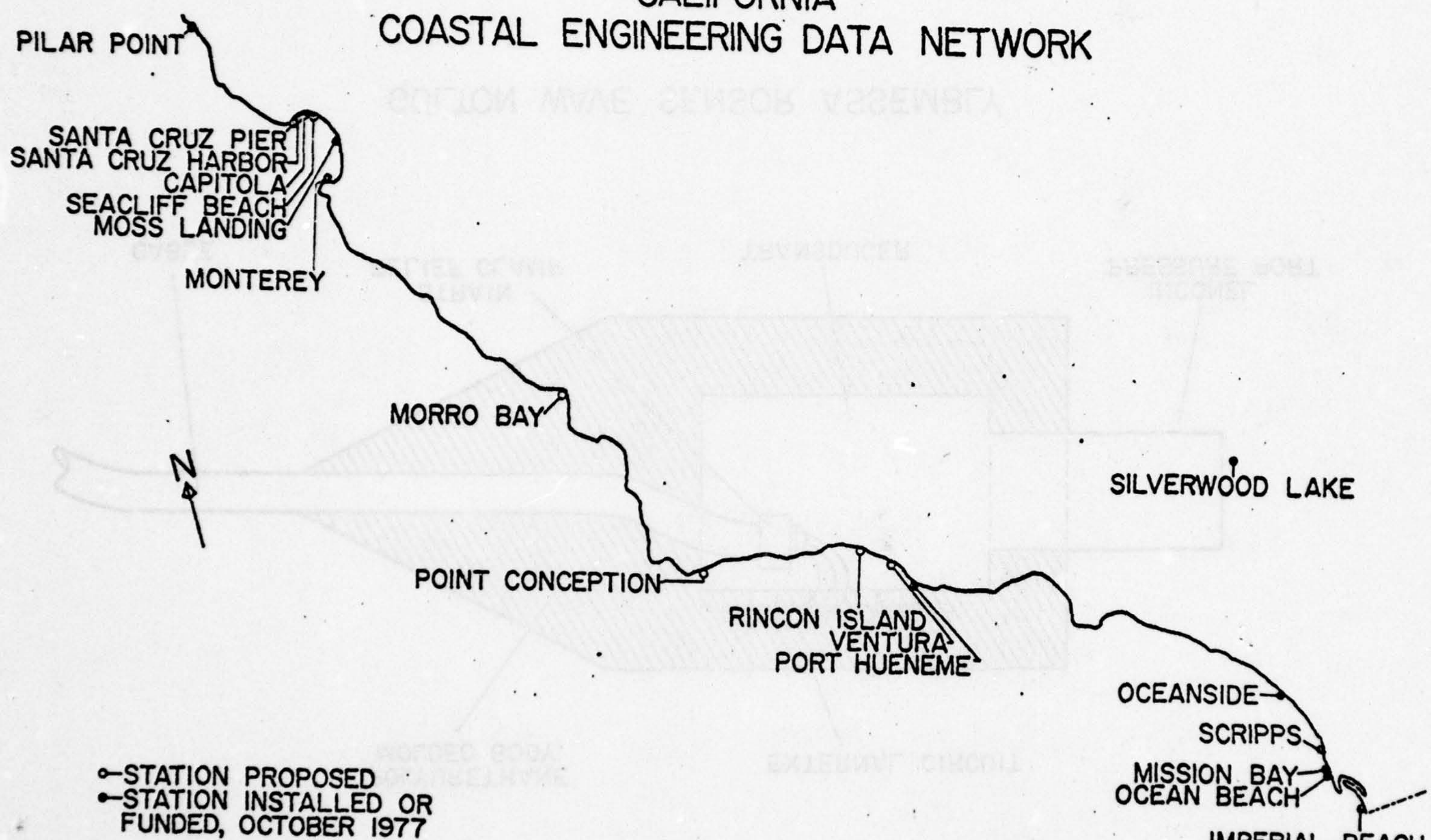
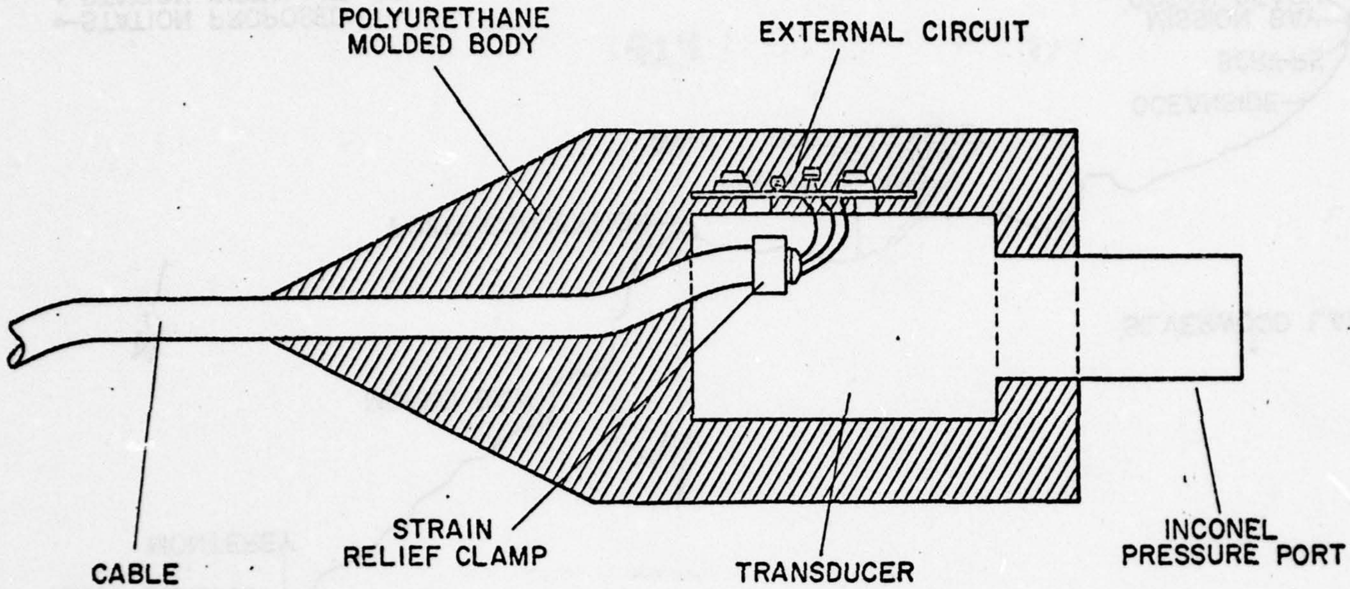
CALIFORNIA
COASTAL ENGINEERING DATA NETWORK





GULTON WAVE SENSOR ASSEMBLY

FIGURE

SAMPLING SPECIFICATIONS

CALIFORNIA COASTAL WAVE NETWORK

Sampling rate 1 hz

Sampling duration about 17 min
(1024 samples)

Sampling interval (standard)
every 10 hours
(interval can be decreased during periods of special interest)

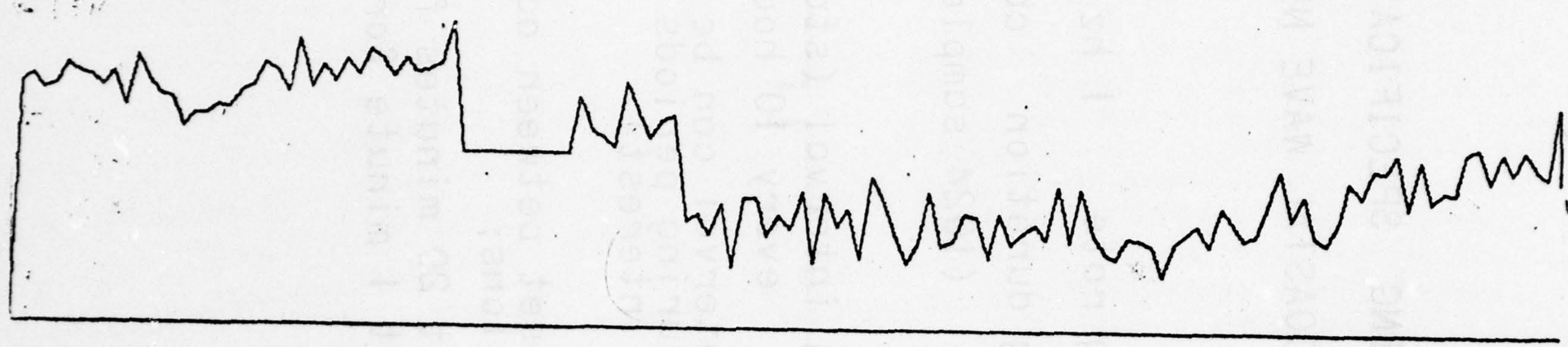
Time offset between adjacent stations:

about 20 minutes for FM
about 1 minute for digital

25 OCTOBER,1977 SIO-HL

SIGNIFICANT WAVE HEIGHT-1345 TO 1615 PDT-24 OCT,1977-OCEANSIDE

CHAN 1 MAX= 144 MIN= 0 MEAN= 77.39 DATA 1- 134 SCALE X 4.0
AVERAGED OVER 56 SECONDS



SPECTRAL ANALYSIS SPECIFICATIONS

CALIFORNIA COASTAL WAVE NETWORK

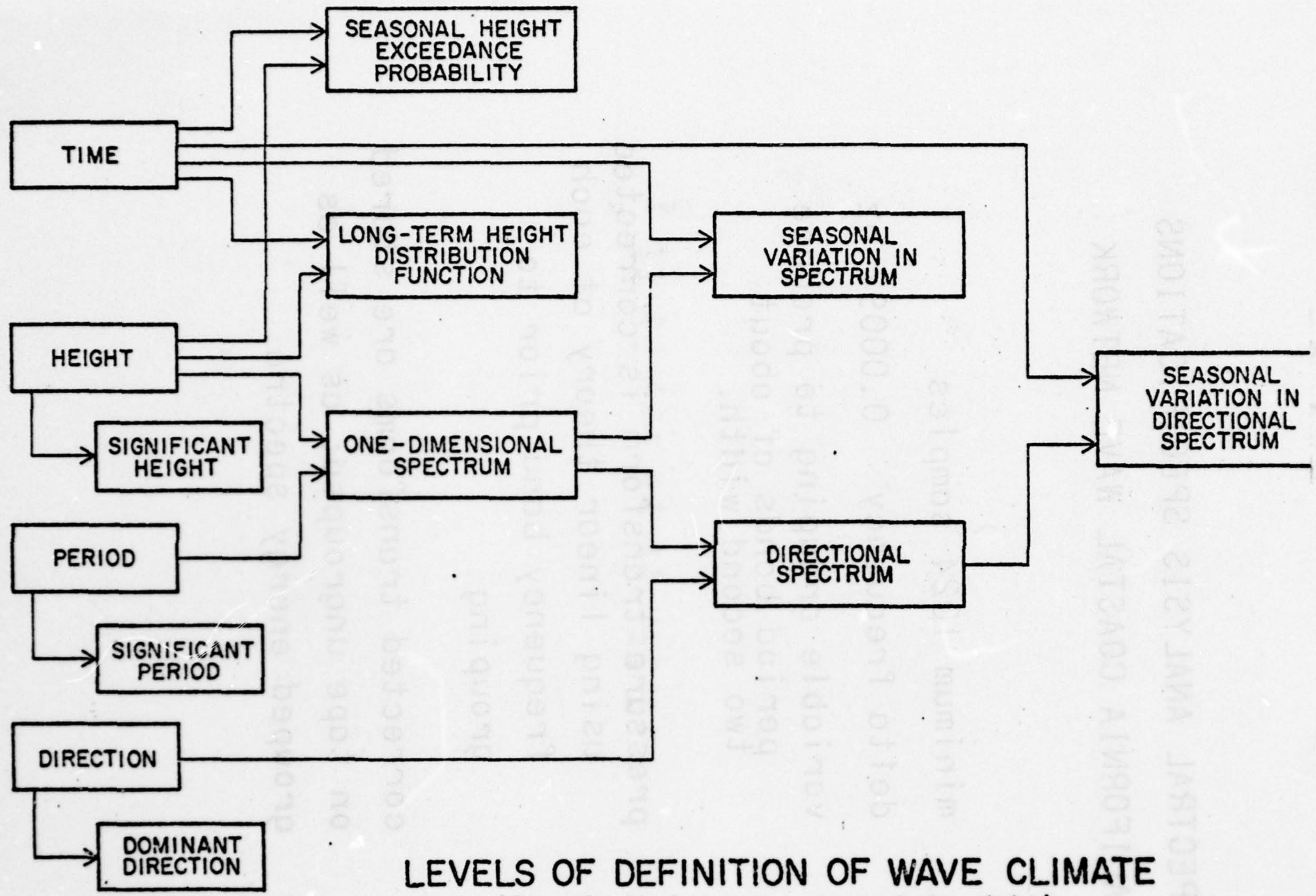
minimum 1024 samples

delta frequency 0.00097 hz

variable grouping to produce
period bands of about
two second width.

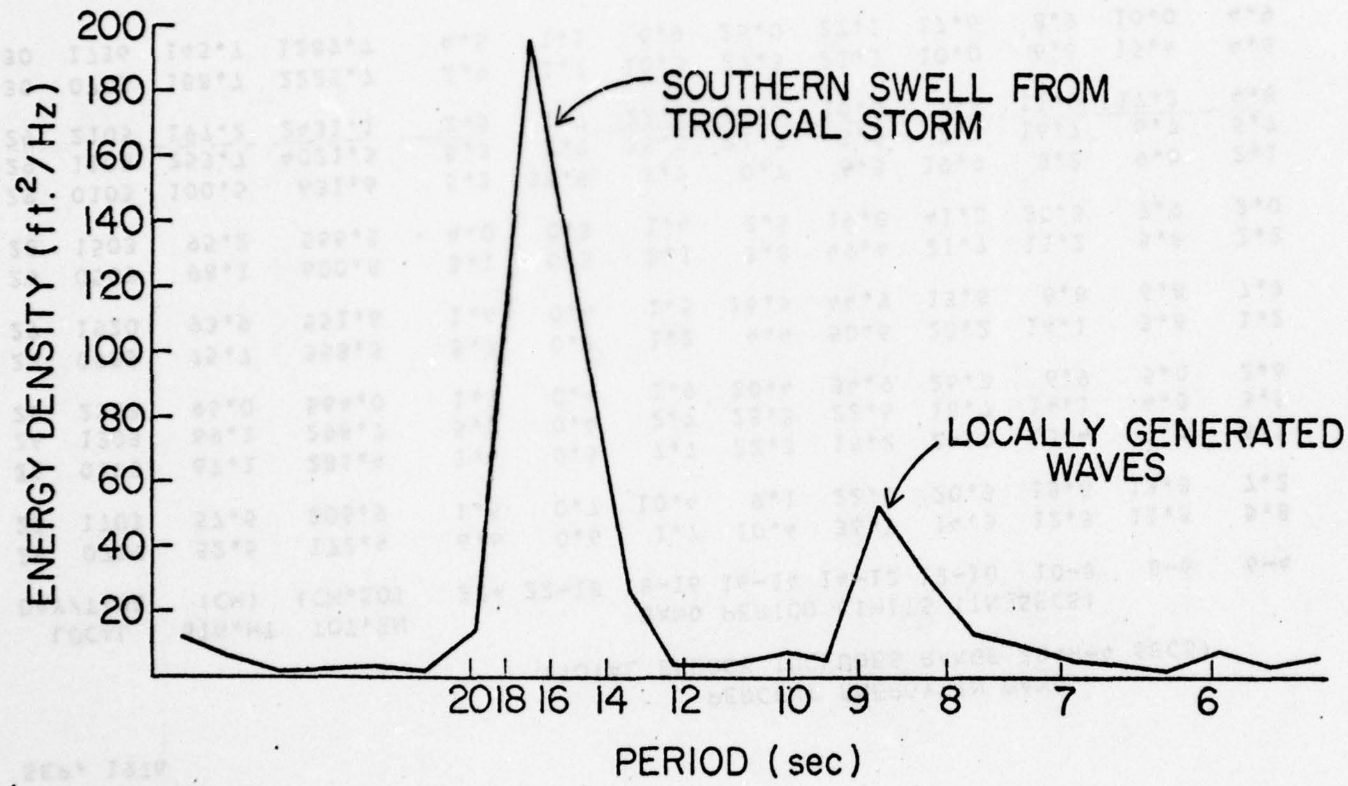
pressure transform is corrected
using linear theory at each
frequency band prior to
grouping

corrected transforms are stored
on tape ungrouped; as well as
grouped energy spectra.



LEVELS OF DEFINITION OF WAVE CLIMATE
(Complexity increases toward the right)

SPECTRUM OF EXTREME CONDITION DURING 1976
OUTSIDE MISSION BAY ENTRANCE (SAN DIEGO)
(11 A.M., 29 SEPT. 1976), SIGNIFICANT WAVE HEIGHT = 8.3 FT.

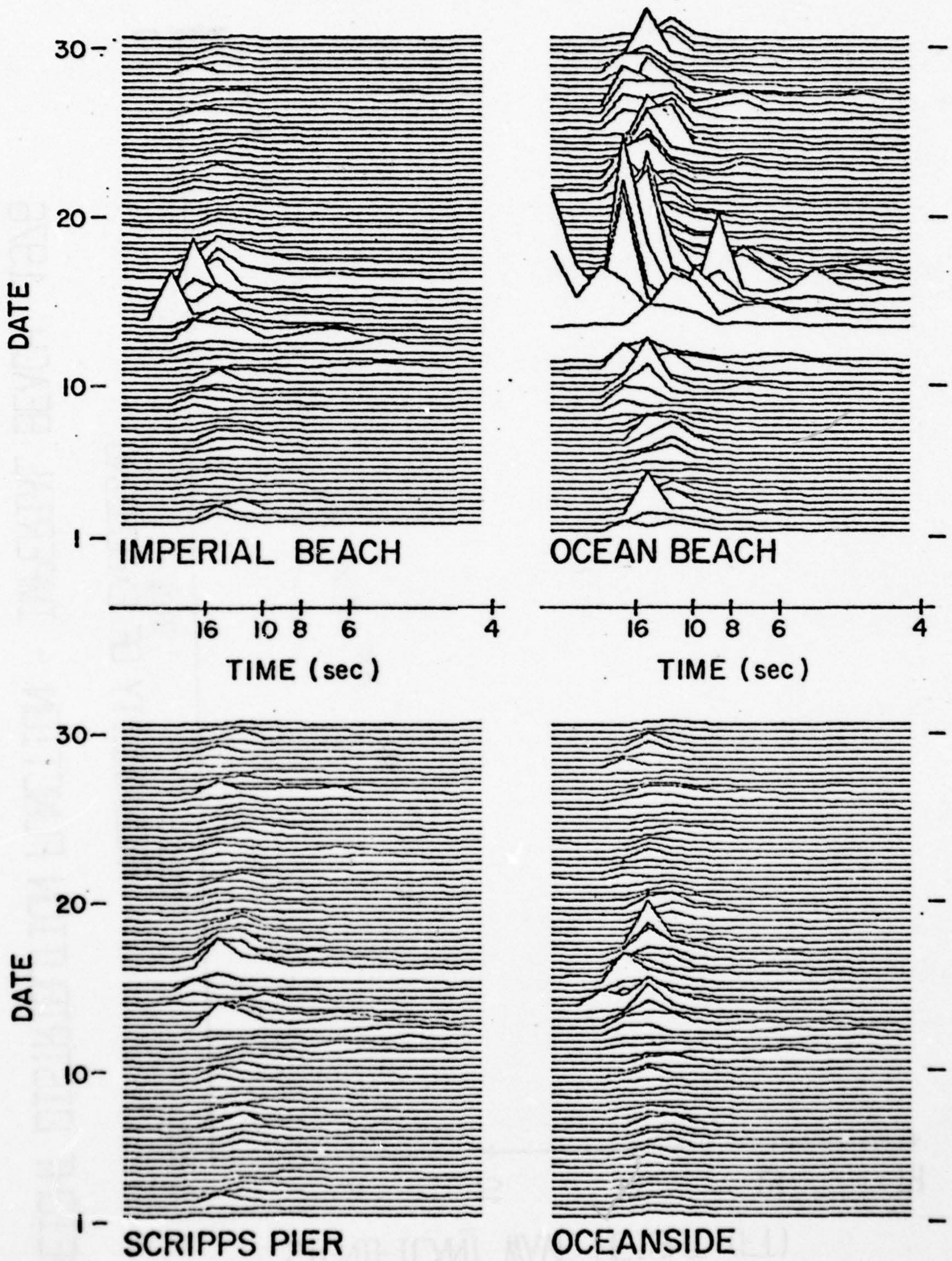


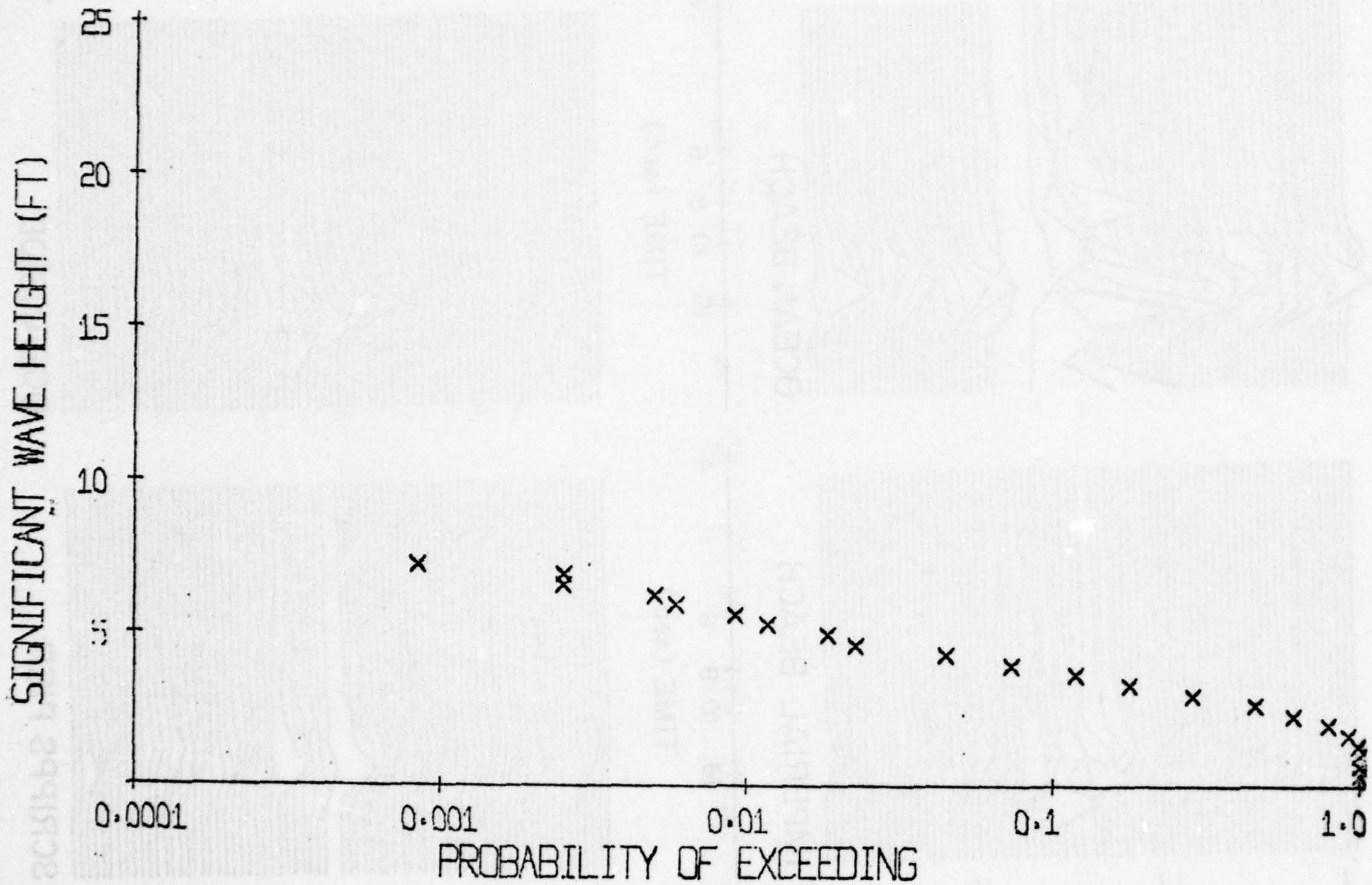
OCEAN BEACH
SEP. 1976

PERCENT ENERGY IN BAND
(TOTAL ENERGY INCLUDES RANGE 2048-4 SECS)

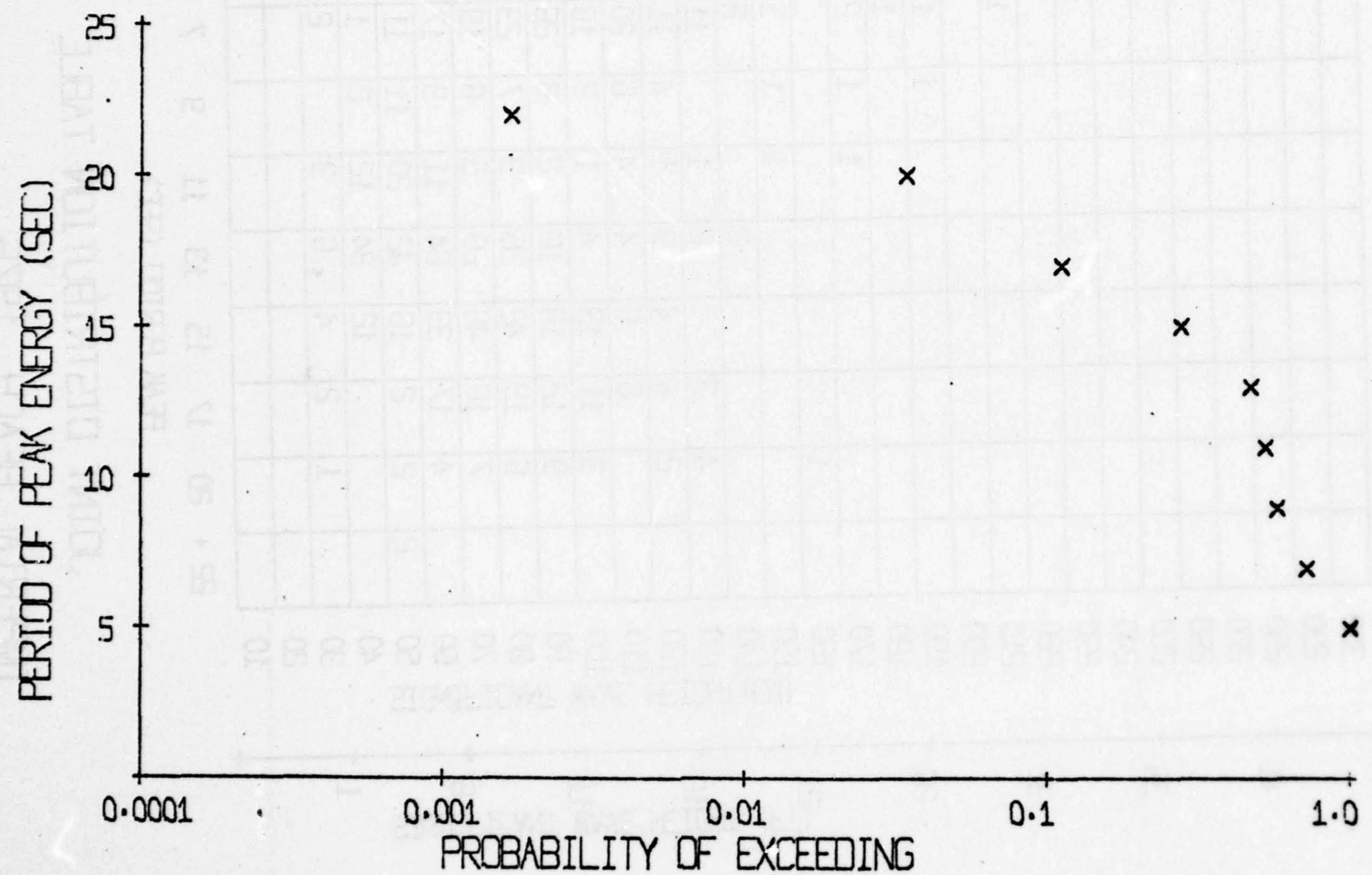
LOCAL DAY/TIME		SIG.HT (CM)	TOT.EN (CM.SQ)	BAND PERIOD LIMITS (IN SECS) 22+	22-18	18-16	16-14	14-12	12-10	10-8	8-6	6-4
25	0719	52.5	172.4	6.6	0.6	1.7	10.4	36.7	14.3	12.3	11.8	5.8
25	1703	57.5	206.9	1.5	0.7	10.4	9.1	22.0	20.3	15.6	13.3	7.2
26	0303	67.1	281.4	1.4	0.3	7.7	22.3	18.2	24.9	13.4	7.0	4.7
26	1303	69.1	298.7	5.2	0.4	2.7	28.5	22.6	18.7	14.1	4.3	3.5
26	2303	95.0	564.0	1.7	0.4	1.9	20.4	34.9	26.3	6.9	5.0	2.6
27	0903	75.7	358.3	3.7	0.8	1.2	4.4	50.6	20.2	14.1	3.8	1.2
27	1920	93.9	551.6	1.6	0.4	1.5	16.5	44.9	13.8	6.8	6.8	7.7
28	0503	98.1	600.8	3.1	0.3	2.3	3.8	49.4	21.7	11.2	5.8	2.2
28	1503	95.2	566.5	4.0	0.3	1.4	2.5	19.8	41.8	20.3	7.9	2.0
29	0103	100.5	631.6	5.3	38.5	8.7	0.7	6.5	19.9	9.2	9.0	2.1
29	1103	253.7	4021.3	5.3	2.9	35.3	21.7	3.3	2.3	16.7	6.7	5.7
29	2103	197.2	2431.1	2.5	1.7	12.9	32.3	10.0	7.6	11.0	17.2	4.8
30	0703	188.7	2225.7	2.9	1.7	10.3	27.3	21.3	10.0	6.6	15.4	4.5
30	1736	143.7	1289.7	4.5	1.1	0.9	25.0	27.1	17.6	8.9	10.0	4.9

WAVE ENERGY SPECTRA DURING NOVEMBER 1976
(Figure from Seymour et al, 1977)





HEIGHT DISTRIBUTION FUNCTION - IMPERIAL BEACH 1976



PERIOD DISTRIBUTION FUNCTION - IMPERIAL BEACH 1976

TOTAL OF 1191 OBSERVATIONS

SIGNIFICANT WAVE HEIGHT (FT): 46, 41, 36, 31, 26, 21, 16, 11, 6, 1

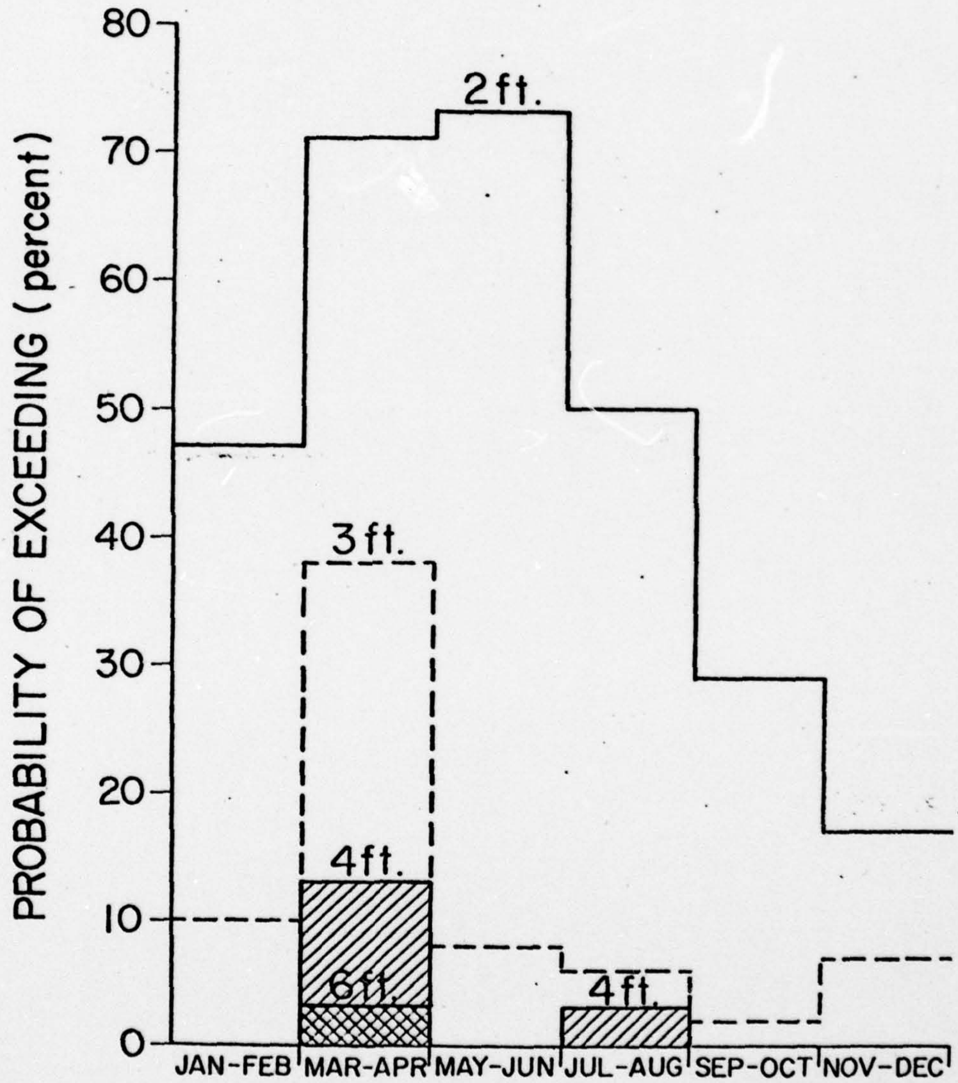
SIGNIFICANT WAVE HEIGHT (CM)	22 +	20	17	15	13	11	9	7	5
300									
290									
280									
270									
260									
250									
240									
230									
220									1
210								1	1
200									
190							1	1	1
180								1	
170						1	1	2	
160		1							2
150						1	1	5	1
140					2			2	1
130		4	3		2	1		11	5
120		2	4	4	3	1	4	11	5
110			6	6	4	4	6	20	8
100		3	11	13	4	1	2	18	19
90		9	12	18	15	2	8	26	35
80		6	19	42	35	3	7	23	73
70		7	16	46	20	5	8	19	59
60		4	17	33	64	11	9	17	60
50	2	2	2	16	42	20	11	11	48
40				12	34	12	2	1	16
30		1	2	4	6	3		2	1
20									
10									

PEAK PERIOD (SEC)

JOINT DISTRIBUTION TABLE

IMPERIAL BEACH 1976

SEASONAL PROBABILITY OF EXCEEDING
VARIOUS SIGNIFICANT WAVE HEIGHTS
IMPERIAL BEACH , CALIFORNIA (1976 DATA)



INCLOSURE 6

A SLOPE ARRAY FOR ESTIMATING WAVE DIRECTION

Richard J. Seymour

California Department of Navigation
and Ocean Development

Alan L. Higgins

Scripps Institution of Oceanography

INTRODUCTION

The concept of measuring wave directional properties from a knowledge of the time history of sea surface slope is well known. Longuet-Higgins, Cartwright and Smith (1963) and Misuyasu, et al., (1975) report on deep water investigations using a surface following buoy. In shallow water, a fixed array of gages offers some operational advantages over moored buoys. The California Coastal Engineering Data Network project, jointly sponsored by the Department of Navigation and Ocean Development, and the Sea Grant Program, has undertaken investigations of the feasibility of employing small arrays of bottom-mounted pressure transducers to estimate wave direction just outside the surf zone to provide data for predicting longshore transport of sediment.

THEORY

Longuet-Higgins, et al., (1963) shows that the time series

$$\eta(t),\ \frac{\partial\eta}{\partial x}(t),\ \text{and}\ \frac{\partial\eta}{\partial y}(t)$$

may be used to obtain estimates of the first five Fourier coefficients of the directional spectrum $E(f,\theta)$

$$a_n + ib_n = \frac{1}{\pi}\int_0^{2\pi} e^{ni\theta}\, E(f,\theta)\, d\theta \qquad (1)$$

One of these coefficients, $C_{\eta_x\eta_y}$, is the cospectrum of η_x and η_y.

$$C_{\eta_x\eta_y}(f) = \int_0^{2\pi} K^2 \cos\theta\sin\theta\, E(f,\theta)\, d\theta \qquad (2)$$

where K = wave number

For any frequency band, i, $(S_{xy})_i$, the longshore component of shoreward directed momentum flux is given by

$$(S_{xy})_i = n_i \sum_{\theta=-\frac{\pi}{2}}^{\frac{\pi}{2}} E(\theta,i) \cos\theta \sin\theta \tag{3}$$

$$\text{Therefore, } (S_{xy})_i = \frac{n_i}{K_i^2} (C\eta_x\eta_y)_i \tag{4}$$

Thus, if (S_{xy}) and $(E_{total})_i$ can be estimated, then an apparent wave angle, $\hat{\theta}$, can be calculated such that

$$(S_{xy})_i = (E_{total})_i \, n_i \cos\hat{\theta} \sin\hat{\theta} \tag{5}$$

It can be seen from equation 5 that the apparent angle, $\hat{\theta}$, is an estimate of the one approach angle that would result in the same longshore component of momentum flux within that frequency band as the sum of the contributions from all approach angles in the real wave field. Thus, as opposed to concepts like significant angle, average angle, etc., $\hat{\theta}$ is an estimate of a precisely defined quantity and it can be readily compared to estimates obtained from other means of measuring wave directional characteristics (i.e., directional spectra).

METHOD OF ANALYSIS

Three bottom-mounted pressure transducers are arranged at the corners of a right triangle such that they form one gage pair parallel to the contours of constant depth and a second gage pair perpendicular to the first. A constant surface slope is assumed between each pair of transducers.

$$\eta_x = \frac{\eta_1 - \eta_2}{L_x} \tag{6}$$

$$\eta_y = \frac{\eta_3 - \eta_2}{L_y} \tag{7}$$

η_x is the slope in the offshore direction, η_y is the slope in the longshore direction and L_x and L_y are the offshore and longshore gage lengths, respectively.

The Fourier transforms are calculated for the time series of pressure from each transducer and the standard correction from linear wave theory is applied to obtain the transforms of surface elevation at each point. From the linearity of Fourier transforms and equations 6 and 7, the transforms of the slope components can be obtained:

$$F_{\eta_x} = (F_{\eta_1} - F_{\eta_2})\, L_x^{-1} \tag{8}$$

$$F_{\eta_y} = (F_{\eta_3} - F_{\eta_2})\, L_y^{-1} \tag{9}$$

Sufficient smoothing is performed on periodograms obtained from these transforms to estimate $X_{\eta_x\eta_y}(f)$, the cross spectrum of η_x and η_y.

Substituting

$$C_{\eta_x\eta_y}(f) = \mathrm{Re}\left\{X_{\eta_x\eta_y}(f)\right\} \tag{10}$$

into equation 4 and combining with equation 5 yields

$$\sin\hat{\theta}\cos\hat{\theta} = \frac{\mathrm{Re}\left\{X_{\eta_x\eta_y}(f)\right\}}{E_{(f)}\ K^2} \tag{11}$$

and

$$\hat{\theta} = \frac{1}{2}\sin^{-1}\left[\frac{2\ \mathrm{Re}\left\{X_{\eta_x\eta_y}(f)\right\}}{K^2\ E(f)}\right] \tag{12}$$

ERROR ANALYSIS

Two sources of errors can be identified for this method. The first is the error in measuring pressure caused by the instrument and data system resolution and noise from various sources. This is assumed to be a broadband random error. The effect in the frequency domain of slope measurement error is of the form

$$E = \frac{2\sigma \cosh(Kh)}{L} \tag{13}$$

where h = water depth
and σ = standard deviation of measurement error

The second source of error arises from approximating the slope of a sinusoidal component by measurements at three finitely separated points. The effect of this error on the estimation of a slope component can be shown to be

$$E_j = \eta_j \left[1 - \frac{\sin\left(\frac{KL_j}{2} M\right)}{\left(\frac{KL_j}{2} M\right)} \right] \qquad (14)$$

$$\text{where } M = \begin{cases} \cos\theta, & j = x \\ \sin\theta, & j = y \end{cases}$$

Thus the combined errors for the estimation of slope components are

$$E_x = \eta_x \left[1 - \frac{\sin\left(\frac{KL_x}{2} \cos\theta\right)}{\left(\frac{KL_x}{2} \cos\theta\right)} \right] + \frac{2\,\sigma\cosh(Kh)}{L_x} \qquad (15)$$

and

$$E_y = \eta_y \left[1 - \frac{\sin\left(\frac{KL_y}{2} \sin\theta\right)}{\left(\frac{KL_y}{2} \sin\theta\right)} \right] + \frac{2\,\sigma\cosh(Kh)}{L_y} \qquad (16)$$

The resulting error in estimating S_{xy} is the cospectrum of the offshore and longshore slope errors. To first order this is

$$\bar{S}_{xy}(f) = \frac{n}{K^2}\left\{A_{n_x}(f)A_{n_y}(f)\left[2-\frac{\sin\left(\frac{KL_x}{2}\cos\theta\right)}{\left(\frac{KL_x}{2}\cos\theta\right)}\right.\right.$$

$$\left.\left.-\frac{\sin\left(\frac{KL_y}{2}\sin\theta\right)}{\left(\frac{KL_y}{2}\sin\theta\right)}\right]+2\,\sigma\cosh(Kh)\left[\frac{A_{n_x}(f)}{L_y}+\frac{A_{n_y}(f)}{L_x}\right]\right\} \quad (17)$$

where A_{n_x} = amplitude spectrum of n_x

When a triangular array is used and one transducer is shared by both gage pairs, an additional bias error is introduced. Discussion of this crossproduct error is beyond the scope of this paper. However, the error may be eliminated completely if four transducers are used so that no transducer sharing is required.

ARRAY GEOMETRY AND GAGE LENGTH SELECTION

It can be seen from equation (17) that errors are a function of the wave climate to be measured as well as the gage lengths employed. Thus, the dimensions which would result in minimal error vary both with season and location.

Wave climate records of over one year in length exist at Scripps pier and several other locations as described in Seymour, et al. (1977). Four average seasonal frequency spectra of three months' length (fall, winter, spring, summer) were computed. Best gage lengths based on these wave climate averages were found to vary only slightly from one to another. This suggests that the choice of array dimensions by this method exhibits some stability with respect to the seasons.

For practical reasons, it may be desirable to use gage lengths which are shorter than the computed optimum, particularly in the longshore direction. The decision to do this should be made in the light of resulting errors.

System reliability may be increased by employing one redundant transducer in a four-gage rectangular array.

EXPERIMENTAL VERIFICATION

A subscale array was evaluated in the wind wave channel at the Hydraulics Laboratory at Scripps Institution of Oceanography. The gage lengths were 90 cm in both directions. A simulated random sea with a peak period of about four seconds was employed and the array was rotated through several angles relative to the center line of the wave channel to provide a number of approach directions. The pressure transducers used in this experiment were the Gulton differential transformer type as described in Seymour and Sessions (1976) and have an assumed standard deviation measurement error of one mm. It can be seen from equation 13 that scaling down the gage length for a laboratory experiment without scaling down the measurement error by the same ratio will result in an increase in the slope error proportional to the scale factor. Figure 1 shows the results of one of the runs with an approach angle of 20 deg. The agreement between predicted and measured S_{xy} is seen to be quite good over the portion of the spectrum where significant energy exists.

Figure 2 shows the angle estimation from the same experiment. The error in estimating the approach angle can be seen to be a maximum of a few degrees over the full range of interest. This is a particularly gratifying result since the measurement error scales unfavorably as noted above.

The large deviation in predicted angle at low frequencies, which occurs in a range where there is not a significant contribution to S_{xy}, may possibly be caused by reflection of these very long waves from the beach in the wave channel. Since the array cannot distinguish the 180 deg. direction ambiguity, reflected energy can bias the estimate of S_{xy} and, therefore, of the incidence angle.

Figure 3 shows the errors in predicting S_{xy} in this experiment compared to the prediction of the error given by equation (17). The agreement of the predicted and actual errors is very good in the area where S_{xy} is largest.

FIELD EVALUATION

A full-scale array with a 6 m gage length in both the offshore and the longshore directions has been installed at Torrey Pines Beach in conjunction with the five-gage linear array operated by the Shore Processes Laboratory and described in Pawka (1977). Data have been recorded concurrently with the slope and the linear array under a variety of wave climates and are presently being analyzed for comparison. The results will be reported in a future publication.

REFERENCES

1. Longuet-Higgins, M. S., Cartwright, D. E., and Smith, N. D., "Observations of the Directional Spectrum of Sea Waves Using the Motions of a Floating Buoy." Ocean Waves Spectra, Proceedings of a Conference, Prentice-Hall, Inc., Englewood Cliffs, N. J., 1963.

2. Mitsuyasu, H., et al., "Observations of the Directional Spectrum of Ocean Waves Using a Cloverleaf Buoy," Journal of Physical Oceanography, Vol. 5, 1975, pp. 750-760.

3. Seymour, R. J., and Sessions, M. H., "A Regional Network for Coastal Engineering Data." Proc., Fifteenth Int. Conf. on Coastal Engineering, Honolulu, Hawaii, July 1976.

4. Seymour, R. J.; Sessions, M. H.; Wald, S. L.; and Woods, A. E.; "Coastal Engineering Data Network Second Semi-Annual Report, July 1976 to December 1976." Institute of Marine Resources, University of California, IMR Ref. 77-103. Sea Grant Pub. No. 56. January 1977.

5. Pawka, S. S., "Linear Arrays." Proceedings of a Workshop on Instrumentation for Nearshore Processes, La Jolla, California, June 1977.

COMPARISON OF PREDICTED AND MEASURED S_{xy} FOR LABORATORY EXPERIMENT WITH 20 DEG. INCIDENCE ANGLE (84 DEGREES OF FREEDOM)

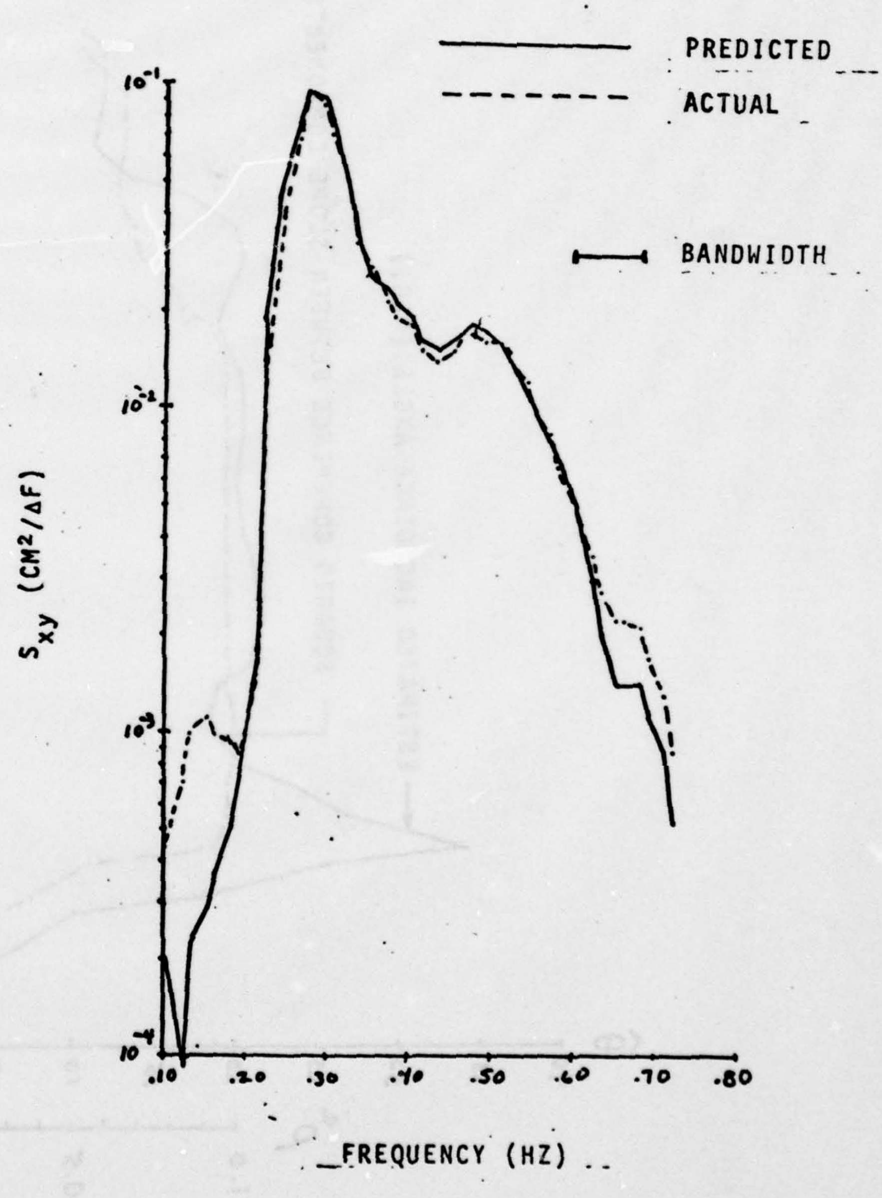
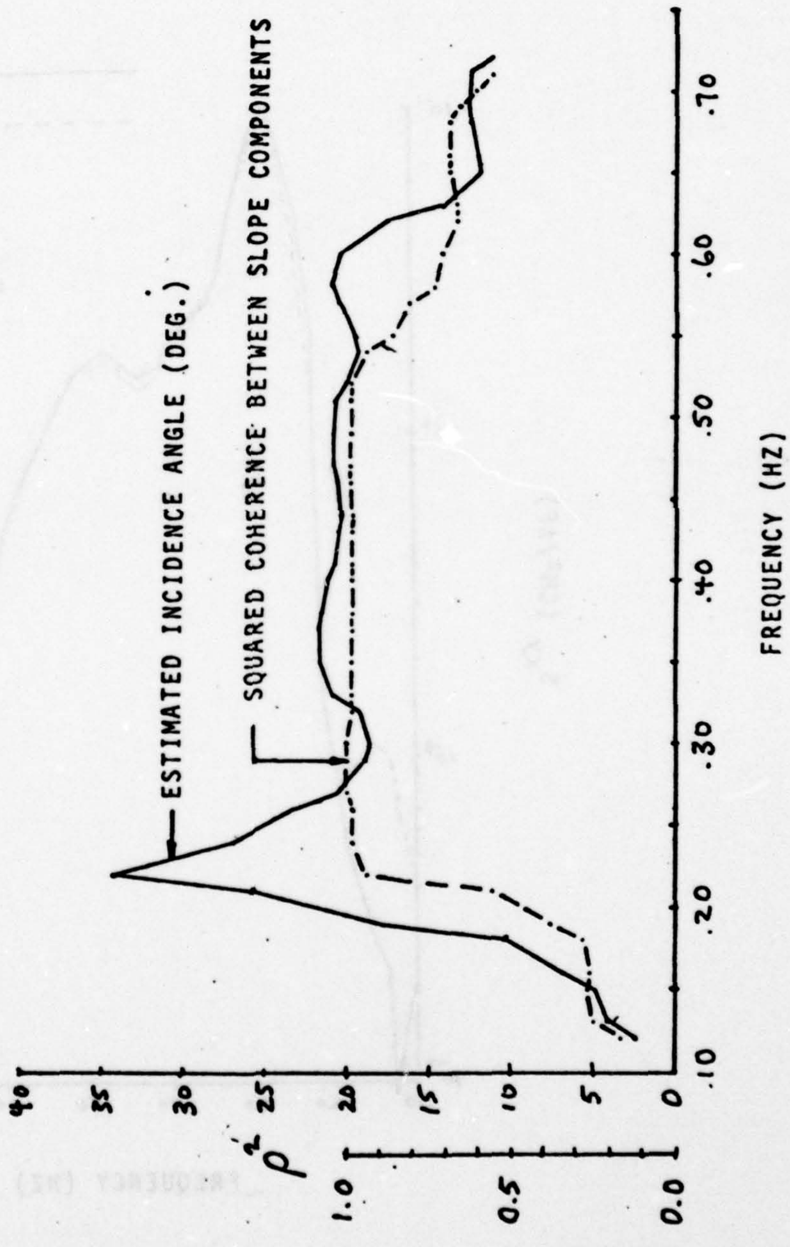
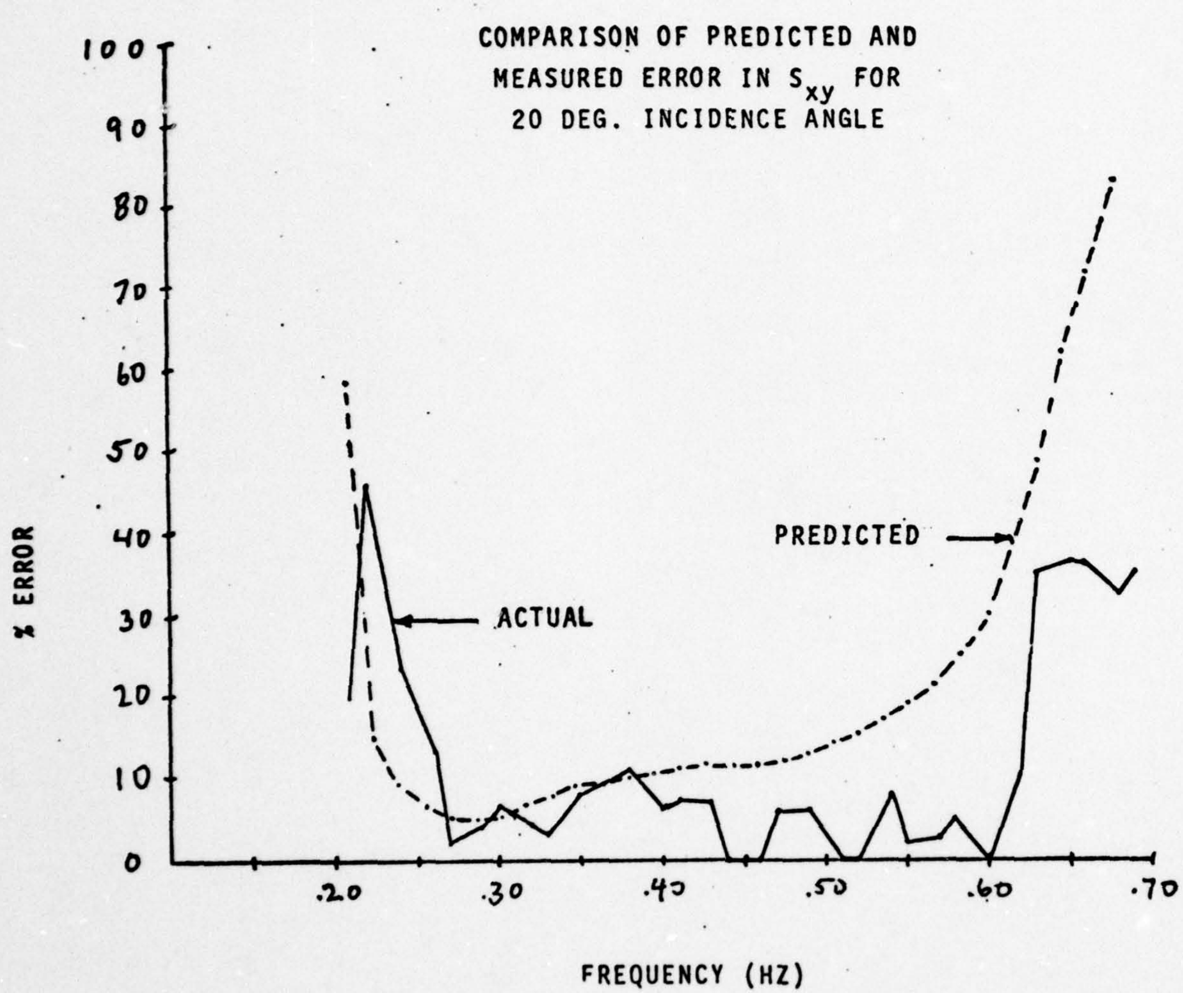


FIGURE 1



ESTIMATED INCIDENCE ANGLE (FOR MEASURED ANGLE OF 20 DEG.) AND SLOPE COHERENCE

FIGURE 2



COMPARISON OF PREDICTED AND
MEASURED ERROR IN S_{xy} FOR
20 DEG. INCIDENCE ANGLE
% ERROR
100
90
80
70
60
50
40
30
20
10
0
ACTUAL
PREDICTED
.20
.30
.40
.50
.60
.70
FREQUENCY (HZ)

FIGURE 3

"Wave direction" has no specific meaning when applied to a random sea.

Using a directional spectrum, we get a directional distribution for each period band.

To obtain a single significant angle, must decide on a way of "condensing" the directional spectrum.

An important quantity for predicting sediment transport, S_{xy}, is already condensed as required.

$$E(f,\theta) \longrightarrow S_{xy}(f)$$

PRINCIPLE OF "SLOPE ARRAY"

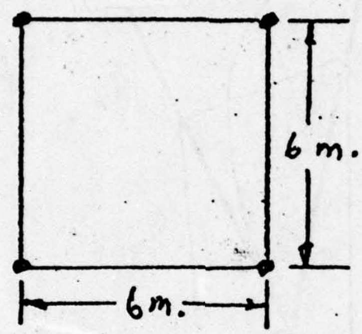
S_{xy} is longshore component of shoreward directed momentum flux.

$$= \sum_f \sum_\theta E(f,\theta)\cdot n\cdot \sin\theta \cdot \cos\theta$$
$$= \left\langle \frac{\partial\eta}{\partial x}\cdot\frac{\partial\eta}{\partial y}\right\rangle = \langle \eta_x \eta_y \rangle$$

In the frequency domain, the average product $\langle \eta_x \eta_y \rangle$ can be estimated, giving a spectrum of S_{xy}.

Together with the measured energy spectrum, a representative angle θ is computed. If all waves were incident at θ, S_{xy} would be the same as that of the observed distribution.

ARRAY CONFIGURATION

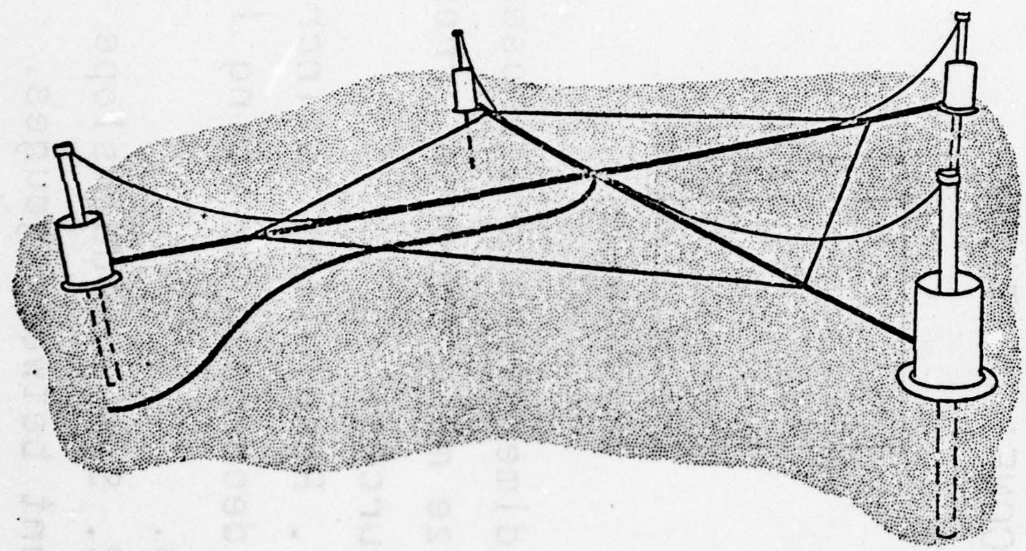


Array dimensions are chosen to minimize mean squared error from two sources:

1. Resolution is increased and noise decreased by using large gauge length.

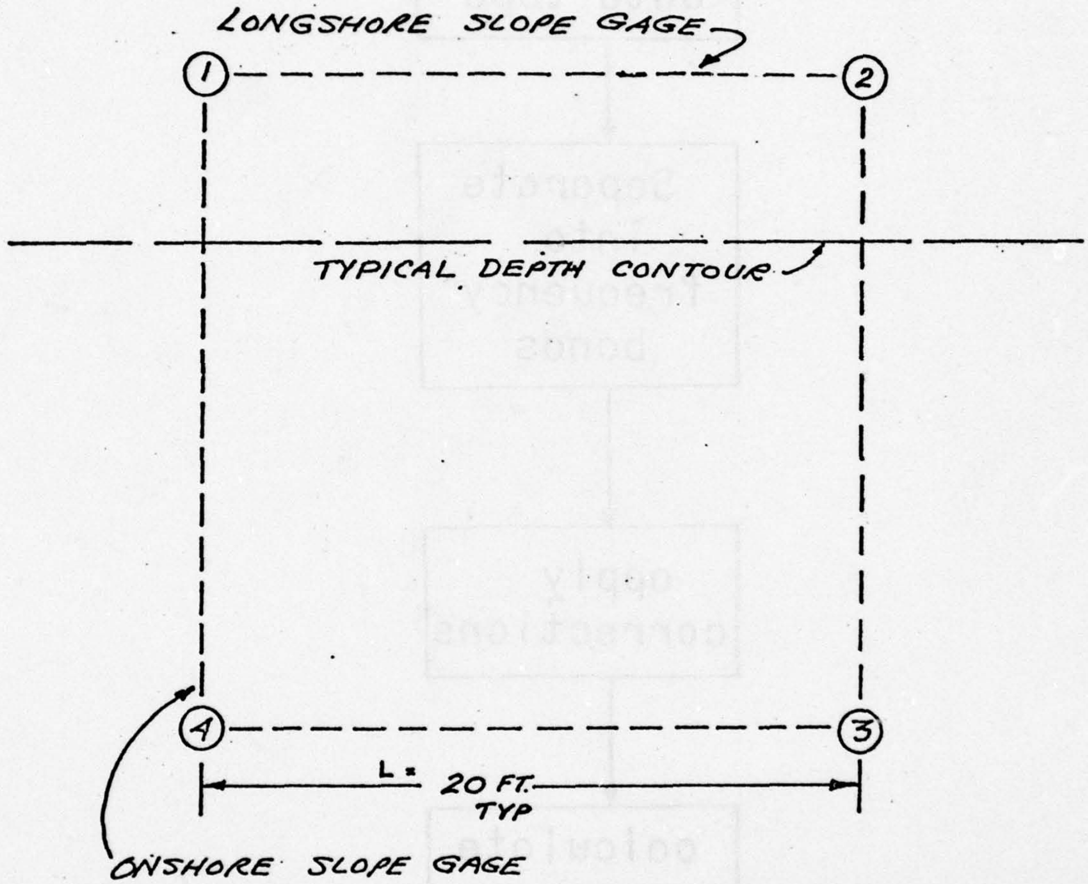
2. Sea surface slope is not constant between gauges.

Redundant use of four transducers and square geometry facilitates array operation when one gauge is down.



SLOPE ARRAY FOR MEASURING WAVE DIRECTION

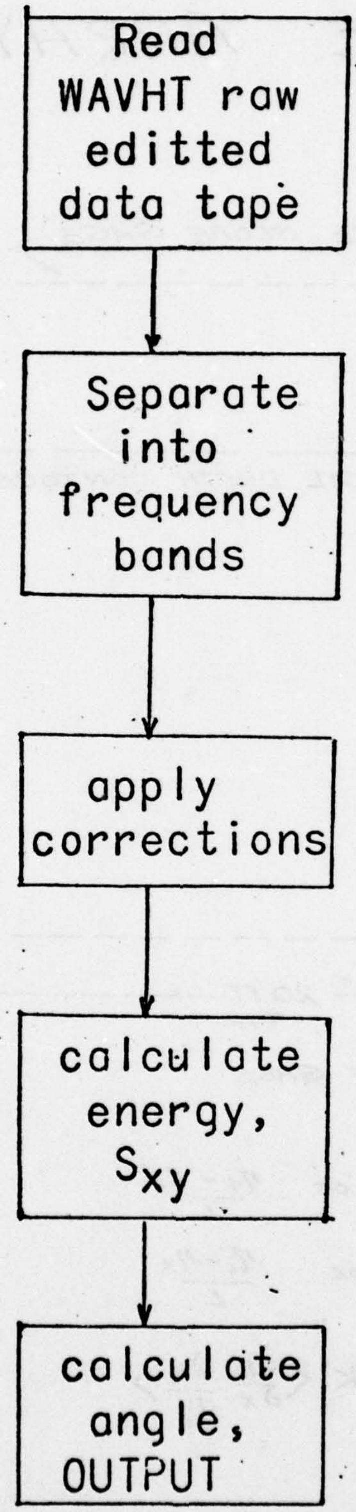
SLOPE ARRAY



$$\frac{\partial \eta}{\partial x} = \frac{\eta_1 - \eta_2}{L} \quad \text{or} \quad \frac{\eta_4 - \eta_3}{L}$$

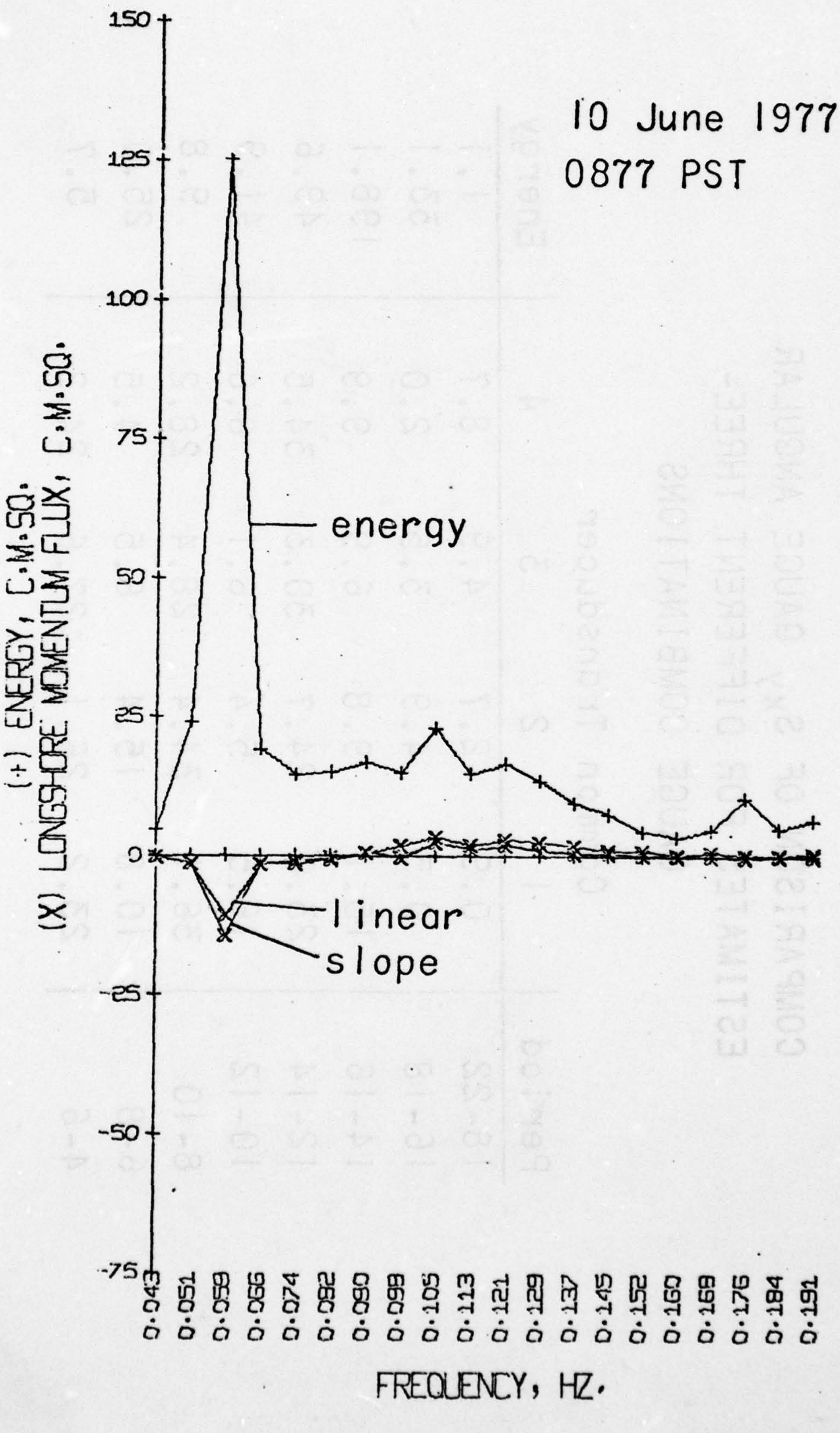
$$\frac{\partial \eta}{\partial y} = \frac{\eta_1 - \eta_4}{L} \quad \text{or} \quad \frac{\eta_2 - \eta_3}{L}$$

$$S_{xy} = K^2 \left\langle \frac{\partial \eta}{\partial x} \frac{\partial \eta}{\partial y} \right\rangle$$


Read WAVHT raw editted data tape
Separate into frequency bands
apply corrections
calculate energy, S_{xy}
calculate angle, OUTPUT

COMPARISON OF S_{xy} GAUGE ANGULAR ESTIMATES FOR DIFFERENT THREE-GAUGE COMBINATIONS

Period	Common Transducer 1	2	3	4	Energy
18-22	0.9	-2.7	4.9	8.7	1.1
16-18	0.5	4.9	3.5	2.0	33.1
14-16	15.1	9.8	6.9	9.9	198.1
12-14	23.0	24.7	30.3	34.5	49.6
10-12	16.5	5.4	6.1	6.6	41.9
8-10	36.1	34.4	28.4	28.2	9.8
6-8	10.8	15.4	6.5	4.5	25.0
4-6	23.2	26.1	27.6	24.2	5.7


10 June 1977
0877 PST
150
125
100
75
50
25
0
-25
-50
-75
(+) ENERGY, C·M·SQ.
(X) LONGSHORE MOMENTUM FLUX, C·M·SQ.
energy
linear
slope
0.043
0.051
0.059
0.066
0.074
0.082
0.090
0.098
0.105
0.113
0.121
0.129
0.137
0.145
0.152
0.160
0.168
0.176
0.184
0.191
FREQUENCY, HZ.

INCLOSURE 7

WAVE DATA NEEDS FOR MODEL STUDIES AND CONSTRUCTION PROJECTS

by

Robert W. Whalin, PhD
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U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi 39180

WORKING DRAFT

Prepared for
OCEAN WAVE CLIMATE SYMPOSIUM
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Incl 7

WAVE DATA NEEDS FOR MODEL STUDIES
AND CONSTRUCTION PROJECTS

by
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INTRODUCTION

Wave data form the basic input for practically every planning, design, operation and maintenance problem concerned with coastal projects of the Corps of Engineers. Extreme waves and water levels are used for determining the size of stone or concrete armor units and the crown elevation for coastal structures (breakwaters and jetties), the elevation of hurricane surge barriers and/or control structures, and for flood plain management. Daily climatologies are needed for optimal scheduling of dredging operations which are constrained to operate in relatively mild wave climates, to determine the required capacity of sand bypassing systems, to evaluate the effect of proposed projects on adjacent shorelines, to plan and design beach-fill projects, to evaluate alternative methods of mitigating beach erosion problems, and to determine the adequacy of alternative borrow sites for beach nourishment. This paper will attempt to discuss the wave data needed for Corps of Engineers projects, present the Corps of Engineers undertakings in these areas, and delineate those areas where we would like to have additional wave data.

HARBOR MODELS (SEA AND SWELL)

The most common type of harbor model study performed is to determine the optimum length, alignment, orientation, and crown elevation of breakwaters, jetties, etc., to assure that wave heights in the navigation channel and mooring area are within some predetermined limit (usually between 1 and 2 ft in the mooring area) for a selected frequency of occurrence storm

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(usually a 10- or 20-year event). Energy can enter the harbor either through the entrance or through or over the breakwater; consequently, both overtopping and energy transmission through the breakwater are usually simulated accurately in these model studies. These harbors are usually small craft harbors or harbors of refuge. Most such model investigations also involve the study of potential shoaling in the entrance channel and/or the effect of the proposed development on sand transport in the area. Wave-induced currents also are usually measured. Sometimes these studies are complicated by rivers which flow through the harbors to the ocean or lake. In such cases, river flows of various discharges also may be modeled. Scales for these various discharges may also be modeled. Scales for these models are undistorted and usually range from 1:50 to 1:125 depending on the wave climate, bathymetry, and problem under study.

Recent studies of this type include models of Ludington Harbor, Michigan; Cattaraugus Creek Harbor, New York; Port Ontario Harbor, New York; Newburyport Harbor, Massachusetts; Wainae Harbor, Oahu, Hawaii; Tau Harbor, American Samoa; Agana Harbor, Guam; and Dana Point Harbor, California (Figures 1 and 2 and Refs. 1-6).

Wave Data Needed. Both extreme wave data and a wave climatology are needed for these studies. The climatological data are used to construct a climatology in the navigation channel and mooring area by inputing deep-water waves covering the entire wave climate (height, period, and direction) and measuring the corresponding height throughout the harbor and approach channels. It is extremely important that the extreme wave data be reliable, have known confidence limits, and include the joint probability distribution of waves and water levels. The crown elevation and stone or concrete armor unit size for the protective structures is determined on a least cost basis taking into account initial expenditure, projected maintenance costs, and protection afforded the harbor. It is impossible to select the optimal plan without the wave data specified.

HARBOR OSCILLATION MOD

Two types of harbor oscillation models are conducted by the Corps

of Engineers: physical models and numerical models. Optimally, in terms of cost, time, and accuracy, both types of models are performed for a given study.

Physical Models. Physical models of harbor oscillations are extremely complex and must be relatively large to decouple harbor resonance from the finite model ocean area, need carefully designed model wave absorbers and filters, and have accurate control of wave generators and wave measuring equipment. Scales for these models may be either undistorted or distorted. The desired end result of the model studies of harbor oscillations is to know the frequency of occurrence of various types of harbor oscillations of a given magnitude in order that this can be translated to a frequency of occurrence of both moored ship response (primarily surge, sway, and pitch) and forces on mooring lines. In addition to the harbor oscillation question addressed, it may be desired to also address problems discussed in the previous section as well as tidal flushing of the harbor.

Two recent physical model studies of harbor oscillations have been conducted; Port Hueneme Harbor (1:100 undistorted scale) and Los Angeles and Long Beach Harbors model (1:100 vertical and 1:400 horizontal scale (Figures 3 and 4 and Refs. 7 and 8).

Numerical Models. Numerical models of harbor oscillations also have been conducted in the past two years upon development of a reliable variable depth harbor oscillation model (Ref. 9). Examples of typical finite element grids, response functions, wave-height contours, and velocity fields are shown in Figures 5-8 and Ref. 10).

Wave Data Needed. In order to adequately prosecute harbor oscillation studies to a proper conclusion, we need to know the frequency of occurrence of long-period (25 sec to 15 minutes) wave energy (directional spectral) incident to the harbor (preferably near the edge of the continental shelf (400- to 600-ft depth). These energy levels are very low. Figures 9 and 10 show some maximum energy levels inside Los Angeles Harbor and just outside the San Pedro breakwater (55-ft depth) obtained from over a 13-month measurement period. Typical energy levels outside the breakwater were two orders of magnitude less than this. To the author's knowledge, the only

successful long-term measurements of such low energy levels were those made by the Waterways Experiment Station in Los Angeles and Long Beach Harbors (Ref. 11 and 12) The measurements needed are even more difficult since they should be made offshore and directional spectra are desired.

For simplicity, this discussion will not concern itself with the many possible mechanisms for exciting harbor oscillations. Long-period wave measurements are probably only needed on the west coast of the United States and in the Hawaiian Islands.

BREAKWATER AND JETTY MODELS

Model investigations of rubble-mound breakwaters, floating breakwaters, and jetties are conducted to determine the optimum functional design of such structures and to minimize the total cost of the structure (initial capitalization plus probable maintenance costs). Both two-dimensional (wave flume) and three-dimensional tests (waves at an angle to the trunk or head-section) are conducted. Models of this type are always undistorted and scales may range anywhere from 1:2 to 1:55 depending on the precise problem under evaluation. Model tests are usually conducted to ascertain a stable design for, perhaps, a 1-in-20 year event and subsequent tests evaluate the consequences of waves exceeding the no damage design wave in order to optimize initial costs and probable maintenance costs. Thus, a frequency of occurrence of damage can be obtained from the model tests (risk computations also can be performed).

Recent studies have been made for Wainae Harbor Breakwater, Oregon Inlet jetties, Nawiliwili Breakwater rehabilitation, Humboldt jetties rehabilitation, the Atlantic Generating Station breakwater (Figures 11-13; and Refs. 3 and 13).

Wave Data Needed. Extreme wave data are required for these studies including the joint probability distribution of waves and water level.

INLET MODELS

Model studies are conducted to either evaluate the optimum length,

alignment, and orientation of proposed jetties to maintain a safe navigation channel through the inlet or to evaluate proposed improvements to existing jetties at tidal inlets. These model studies concern the hydraulics of the inlet-estuarine system and typically attempt to optimize the hydraulic (tidal flow) flow characteristics of the system, to investigate navigation conditions in the entrance channel, and to evaluate wave conditions in the deposition basins (if any) to determine the percent of time dredges can operate for bypassing sand (Figure 14 and Ref. 14). These models may be either undistorted or distorted. Typical veritical scales range from 1:50 to 1:80 and typical horizontal scales range from 1:200 to 1:300. These model studies usually involve measurement of wave conditions in the entrance channel and in deposition basins to determine the frequency of occurrence of waves of a certain height. This information is used to determine if a dredge can operate a sufficient percent of the time. Measurements of potential shoaling conditions in the entrance channel are usually made using an artificial tracer material (Figure 15). Studies of the performance of the weir section (if any) and the deposition basin also are usually made.

Wave Data Needed. A directional spectral wave climatology with known confidence limits and the joint probability distribution of waves and water levels are needed to properly determine the percent of time a dredge could operate and the percent of time navigation through the entrance channel may be precluded.

BEACH EROSION MODELS

Recent projects proposing structural solutions (offshore submerged or semi-submerged breakwaters and/or groins) for mitigating beach erosion problems have benefited greatly from a better understanding and appreciation of the nearshore dynamics and circulation cells through the use of undistorted three-dimensional model studies. These studies entail the measurement of wave heights, wave-induced currents (including rip-currents) and transport of a sediment tracer material in the model. Through an extensive series of measurements covering the entire wave climate (height, period, and direction) for both existing conditions

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and alternative improvement plans, a much better understanding of the physical processes taking place in the prototype is gained, and, consequently, selection of a functional plan to solve the problem is much more probable. It is highly probable that our success rate in mitigating beach erosion problems would be much improved had we conducted more such model studies in the past.

A recent study of this type has been completed for Imperial Beach, California, and it is likely that several more similar studies will be conducted in the next few years.

Wave Data Needed. A directional spectral wave climatology including the joint probability distribution of waves and water level is needed for the studies described above.

CONSTRUCTION PROJECTS

Wave data are extremely important for every Corps of Engineers construction project. First, it is attempted to maximize production by the contractor by initiating projects at times such that maximum advantage can be taken of construction sequences requiring a mild wave climate. Sometimes the consequences of various intensity (wave height and period) storms arriving at selected stages of construction are evaluated in one or more of the model studies previously described. In this manner, risk calculations can be made. In many instances, the contractor may have men and equipment that would be vulnerable to the arrival of unexpected storm waves. Thus, a wave forecast capability is very desirable. Another application of both a short and long term wave forecast is in the optimal scheduling of dredging operations to minimize down time.

Wave Data Needed. An extrème climatology (to evaluate consequences of storms during construction) and a daily climatology are highly desirable for construction projects. The extreme climatology (by month) would be used to formulate an optimal project schedule. A daily and weekly wave climatology forecast would be used to optimize scheduling of dredging operations and to maximize personnel and equipment safety.

CORPS OF ENGINEERS WAVE DATA EFFORTS

The U. S. Army Corps of Engineers is undertaking two principal efforts to solve its most critical wave data needs. Our principal effort is to numerically produce a directional spectral wave climatology including the joint probability distribution of waves and water level, with known confidence limits for the east, west, and gulf coasts of the continental United States and Hawaii. This program was described by Dr. Resio in an earlier paper. A second wave data program has just been initiated by the U. S. Army Engineer Division, South Pacific, as a part of a comprehensive field data collection effort. This program includes the recording of waves at numerous sites up and down the California coast in order to obtain data for specific projects, and some additional information for verification of the nearshore wave transformation portion of the first (numerical wave hindcast effort) major effort.

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ADDITIONAL WAVE DATA ACQUISITION REQUIRED

To our knowledge, there is absolutely no effort, either planned or underway (not only by the Corps of Engineers, but other agencies as well), directed toward measuring the background long period (25 sec to 15 minutes) energy level on the continental shelf of the west coast or offshore the Hawaiian Islands. Such information is of paramount importance for the reliable evaluation of:

(1) Frequency of occurrence of oil tanker response in west coast and Hawaiian harbors.

(2) Frequency of occurrence of LNG and/or LPG response to long-period wave energy on the west coast (Los Angeles Harbor and Oxnard).

President Carter announced two days ago that we were not selling the Alaskan crude to Japan which makes it a virtual certainty that 55 percent of that oil (SOHIO share) will come into Long Beach Harbor, most of which will be pumped to Midland, Texas, for refining. California is running out of natural gas, thus, it is inevi[illegible] hat [illegible] terminals will be constructed. It seems inevitable that [illegible] future will require large offshore energy importing complexes (perhaps for

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both curde and LNG) on both the east, west, and gulf coasts of the United States. Mooring conditions and oscillation characteristics of such complexes are of paramount importance. The message is clear--measure the long period wave climate on a long term (for years) basis. The initial measurements should either be made off Los Angeles and Long Beach Harbor, Port Hueneme, Monterey Bay, or Barbers Point, Hawaii, in that order of priority.

A second area where we need good reliable directional spectral wave data is on either side of the Gulf Stream. Confidence limits for our hindcast programs for the east coast may be increased due to a lack of data on the effect of the Gulf Stream on wave propagation and even wave generation. A relatively long-term well planned experiment to obtain reliable directional spectral wave data across the Gulf Stream is needed.

A network of regional continental shelf directional spectral wave measurements is highly desirable (3 to 6 gages per coast plus Alaska and Hawaii). Each shelf gage or array should perhaps be accompanined by two or three nearshore directional spectral gages or arrays to yield both nearshore statistics and provide a basis for verifying numerical wave transformation theories. These gages and/or arrays should be permanently deployed (20 years to 50 years). The value of such data will be of inestimatible long-term benefit.

All prototype wave measurements must have well-defined accuracy and resolution characteristics for the gages used. Many field programs in the past have suffered greatly because too little attention was paid to these very important problems. Gage reliability also must be carefully analyzed. It is essential to have operational gages and/or arrays during major storms.

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INCLOSURE 8

WES PRESENTATION

at

SPD'S COASTAL WAVE DATA MEETING
26 and 27 October 1977

Introductory Remarks

(1) Dr. Don L. Durham, Waterways Experiment Station (WES), expressed to the South Pacific Division (SPD) WES' appreciation for an opportunity to participate in SPD's Coastal Wave Data Meeting. SPD's efforts to establish and use state-of-the-art techniques and to standardize procedures of wave data collection and analyses is a very progressive idea. The success of SPD's program can have major impact on future Corps programs.

Slide Presentation

(2) WES' presentation, which consisted of the inclosed hardcopies of each slide, was structured to give a general overview of WES' support and recommendations for SPD's California Coastal Data Program in the following categories:

a. WES' general interest in SPD's wave data.

b. WES' requirements and needs for wave information.

c. WES' capabilities in wave measurement and analyses.

d. Phases for detailed consideration during program development (e.g., preacquisition design, preprocessing, analyses, and post-processing).

e. WES' support for SPD's program during design, development, and management.

f. Desire for WES to be considered as a Corp depository for prototype and model wave data with responsibilities for interactive data management with SPD user needs.

g. Set of specific recommendations by WES for SPD's program.

Closing Remarks

(3) In closing, Dr. Durham presented two comments which were considered very important to the theme of this conference and to future

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design efforts in SPD's program. These comments were as follows:

a. The engineering and theoretical considerations in mathematics, statistics, and system design are quite complex as they apply to SPD's program. Some aspects of these principles have been debated and will continue to be debated as advances occur in state-of-the-art methodologies. The debate and decisions of appropriate methodologies and credibility of such techniques should be left to the technical consultants of SPD's program. Having good consultants will assure that SPD's program will be based on state-of-the-art techniques and will be flexible enough to incorporate future advances. For the application engineers (planning and design) in the division and district offices, the most important thing is that SPD's needs and requirements for coastal wave data be defined and firmly established. The bottom line of SPD's program should be to obtain good data to fulfill these requirements.

b. "Preacquisition" design is a very important phase of SPD's program. During this phase, the required data, acquisition system, analyses techniques, and information storage/dissemination system must be designed and developed with final objectives of SPD's program firmly in mind. Although the program's design must be sufficiently flexible to allow small changes in all aspects of the program including its scope, the basic and specific objectives of SPD for good coastal data must be the dominant factor during every phase of the program, especially in the "preacquisition" design phase. To illustrate the importance of the "preacquisition" design phase of a data collection program, Blackman and Tukey (1958) in The Measurement of Power Spectra (p. 54) stated "The third aspect -- planning the measurements or observations to meet requirements--has not been adequately treated. (Both statisticians and engineers concerned with measurement will agree that this is the most vital aspect of all, but will, unfortunately, also have to admit that, all too often, "salvage" work will be required because this third aspect was omitted, and the observations made unwisely.)"

In summary gentlemen, this meeting and future design efforts for SPD's California Coastal Data Program must not only be expeditious and expedient but must be guided by proven scientific knowledge, sound engineering experience, and judicious political management. The importance of these efforts can not be overemphasized. The impact of a successful SPD program will be monumental in guiding future wave data collection efforts by the U. S. Army Corp of Engineers and has the potential of establishing a precedent for any conceivable national program on wave climatology and coastal data management. Due to the lack of available wave climatology data, desperate need for such information, and the vast stratification of requirements and users such as various Federal, state, and local agencies as well as many universities, the Corp must not only consider it's needs, which are major, but has an obligation to consider (wherever it is feasible) the needs and requirements of other users.

WES SLIDE PRESENTATION

WES INTERESTS

PHYSICAL/NUMERICAL MODEL REQUIREMENTS

WAVE INFORMATION STUDY

METHODOLOGY EVALUATION

DESIRED WAVE INFORMATION

SEA/SWELL

- WAVE CLIMATOLOGY SUMMARIES
- EXTREME WAVE INFORMATION
- TWO-DIMENSIONAL AMPLITUDE & PHASE SPECTRA

LONG PERIOD

- TWO-DIMENSIONAL AMPLITUDE & PHASE SPECTRA
- FAR FIELD & NEAR FIELD INFORMATION
- EXTREME EVENTS – TSUNAMI, TYPHOONS AND HURRICANES

WAVE MEASUREMENT

SYSTEM DESIGN & DEVELOPMENT

SYSTEM OPERATION & MANAGEMENT

WAVE ANALYSES

PREACQUISITION DESIGN OF ACQUISITION/ ANALYSIS TECHNIQUES

PREPROCESSING OF DATA

ANALYSES

POSTANALYSIS

PREACQUISITION DESIGN

PHYSICAL PHENOMENA

FREQUENCY RESPONSE

- RANGE
- CUTOFF FREQUENCY
- ALIASING
- SYSTEM RESPONSE
- RESOLUTION

DURATION OF DATA

- STABILITY/PRECISION OF SPECTRA
- RESOLUTION

COST

PREPROCESSING

TRANSLATION

SCALING

EDITING

FILTERING

RESAMPLING

STORAGE

ANALYSES

STATISTICS

COVARIANCE

CORRELATION

AMPLITUDE SPECTRUM

PHASE SPECTRUM

CROSS SPECTRUM

TIME-DEPENDENCE

POSTANALYSIS

WAVE STATISTICS

θ-T-H DISTRIBUTIONS

EXTREME WAVE INFORMATION

GRAPHICS & TABULAR OUTPUT

WES SUPPORT

SYSTEM DESIGN & DEVELOPMENT

PROGRAM MANAGEMENT

INTERACTIVE DATA MANAGEMENT

- DATA DEPOSITORY
- DATA ANALYSES
- USER COMMUNICATION
- SPECIAL REQUIREMENTS
- PERMANENT DATA BASE

TECHNICAL CONSULTANTS

PROGRAM CONSIDERATIONS

ESTABLISH BEFORE DATA ACQUISITION
- REQUIREMENTS
- PROCESSING
- QUALITY CONTROL
- INFORMATION DISSEMINATION

FLEXIBLE SYSTEM DESIGN
- CONTINUOUS UPGRADE
- ROUTINE Q.C. & MAINTENANCE
- VARIABLE SAMPLING
- REAL-TIME AVAILABILITY OF DATA

DIRECTIONAL WAVE INFORMATION
- DEEP AND SHALLOW WATER DATA AT A FEW SITES

ACQUIRE DATA AT 3 TO 6 HOURS ROUTINELY AND HOURLY DURING EXTREME EVENTS

MONITORING OTHER OCEANOGRAPHIC AND METEOROLOGICAL VARIABLES

DATA ARCHIVING AND DISSEMINATION SYSTEM

REGULAR REVIEW BY TECHNICAL CONSULTANTS

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WAVE DATA MEETING. MEMORANDUM FOR THE RECORD,(U)
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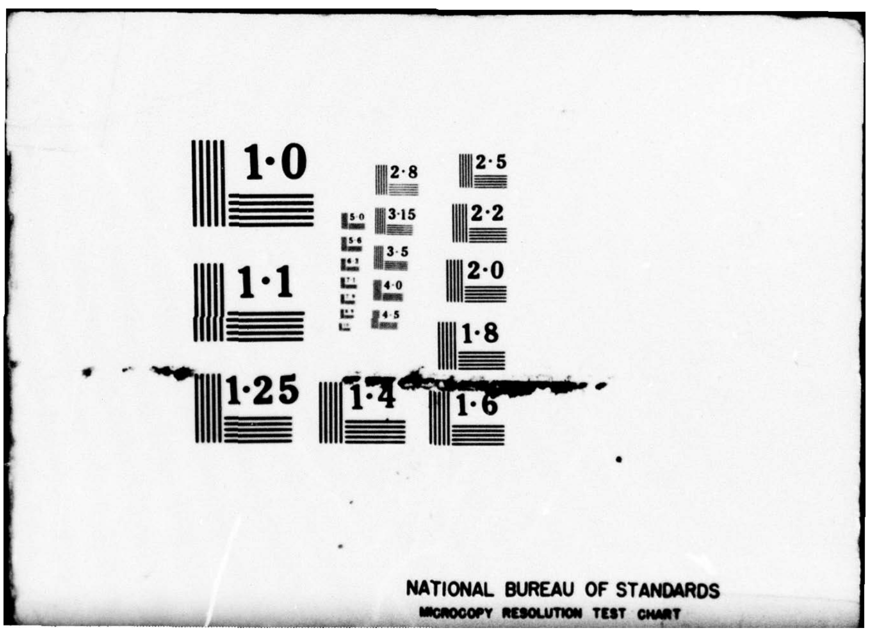
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NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

INCLOSURE 9

25 Oct 77

STANDARDS FOR WAVE DATA ANALYSES

D. LEE HARRIS

CERC

The BEB and CERC have employed three sets of standards for the analyses of pen and ink wave records and one set of standards for the routine analysis of digital wave data from the sea. All of these have been described by Thompson (1977). The logic behind each of these standards for digital wave data have been published by Thompson, Esteva or myself since 1970. The proper references are given by Thompson (1977). The standards are repeated on the first slide.

Slide 2

It must be admitted that these standards are not the best possible solution to all wave recorded analyses problems. In fact, we sometimes find it necessary to deviate from these standards. In particular, longer records, perhaps an hour or longer, must be used for harbor surge problems or other long wave studies. It is sometimes necessary to use shorter records or fewer samples to meet time or storage requirements. We sometimes find it desirable to analyze records that were not recorded with a 1/4 second sampling interval.

Fewer samples may permit recovery of all information in an error free record from pressure gages.

Our data collection program includes pressure gages, Baylor gages, Waveriders and current meters. All of the data can be analyzed in much the same way, if suitable standards are maintained. Higher sampling rates are needed for some type of data and at some locations

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than for others. Standardization of the recording program, as much as practical, facilitates the addition of a new instrument and reduces the potential for human error. The slightly excessive volume of data obtained in this manner is useful for quality control and data evaluation.

We find, however, that many records contain stray electrical impulses or other signals that could not possibly be due to waves in the period range 1-30 seconds. Impossibly steep waves, easily detected in an autographic chart, can lead to serious error in a digital analysis scheme unless detected and removed. Sampling at double the required rate makes detection and correction of this type of noise reliable and reasonably economical. Smoothing the record with an electronic filter blends the error into the data in a way that prevents detection but does not remove the difficulty.

Many of our records contain no detectable errors. Few have more than 1% of the 4096 data points which fail to pass the editing routine. Some records, however, have error rates in excess of 2 1/2% of the samples. These are discarded by our system.

Our computer soft ware can discard any record for which the wave height is too low to justify a full spectrum analyses or one with too much noise and document that fact. We are now using a micro-computer as a wave gage recorder. This permits us to increase the frequency of recording for higher waves. This procedure immediately improves the reliability of statistics about the durability of high

waves and the highest wave in the storm. When supported by suitable theoretical statistics, it should improve the definition of the probability of the highest waves.

Slide 3 Changing time increments by factors of 2 facilitates any evaluation of the advantages of doubling or having the sampling interval. Using rational fractions of seconds facilitates laboratory modeling.

We have conducted several tests to determine the optimum duration of a record. We find that the improvement in the stability of the spectrum generally improves more for the shift from 512 seconds to 1024 seconds than from the shift from 1024 seconds to 2048. Perhaps this is a reasonable application of the rule of thumb that each event should take place at least 30 times within the sample. Waves of 20 seconds are sometimes important. 1024 is the lowest number larger than 20(30) = 600 seconds. We would like to conduct more impirical data on this problem and ~~to~~ we obtain many records long enough to permit more tests, but we have not had the opportunity to conduct them.

In the study of waves, it is necessary to consider the distribution of individual waves within a record, (short term) and the distribution of the significant wave heights over an extended time (long term). In order to eliminate possible confusion between these two types of displays, we have adopted the convention of having short term D.F's slope upward to the right and long term D.F's slope upward to the left.

Slide 4 It must be admitted that instrument systems fail for a variety of reasons, many of which may never be known. We have many records in which pressure gages have given misleading records for an hour or even

a day and then recovered. Baylor gages may acquire a bias equivalent to a shift in mean water level and seem to work well at the new level for several days and then revert to the old value with no human attention. Zero drifts, distinct from the bias just mentioned, may arise from unknown causes. Redundancy in the record may permit one to isolate these errors and eliminate or correct some of them.

Our editing program computes the first statistical moments of the distribution. Each value is tested for normalized deviation from the mean. Deviations expected in fewer than one sample in ten thousand are assumed to be errors. If fewer than five successive doubtful values are found, they are corrected by interpolation. The slope between different values as well as absolute values are tested.

By comparing records from two or more gages at Point Mugu and Oxnard, we find that nearby gages generally agree on wave height within 2%, but that differences of 10% occur too often to be regarded as abnormal. Spectra from nearby gages are generally similar, but for bynodal spectra, each gage may favor a different peak.

Redundancy in gages ~~on~~ of more than the normal number of records reduces the chances of missing critical observations. Doubling the number of records is much cheaper than doubling the number of gages. Two gages at one site are cheaper than two sites. Unbroken records are essential for some purposes; hence redundany can be cost effective.

The skewness and kurtosis measure the non-randomness of the wave field. Both skewness and kurtosis are generally positive.

STANDARDS FOR SPECTRUM ANALYSIS OF
OCEAN WAVE DATA AT CERC

- 1024 SECOND OBSERVATION PERIOD
- .01 HERTZ RESOLUTION
- 4 OBSERVATIONS PER DAY
- 4 SAMPLES PER SECOND

Slide 1

DLH/fms
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PHILOSOPHICAL JUSTIFICATION

- A UNIQUE OBJECTIVE OPTIMUM CANNOT BE DETERMINED
- STANDARDIZATION, WITHIN REASON DESIRABLE, VARIATIONS NECESSARY
- REDUNDANCY USEFUL FOR ERROR DETECTION AND CORRECTION
- MAY NOT ANALYZE ALL OBSERVATIONS BUT CANNOT ANALYZE UNRECORDED WAVES

Slide 2

DLH/fms
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CONVENTIONS

- ONE SECOND, FUNDAMENTAL TIME INTERVAL, I.E. ΔT = 1/8, 1/4, 1/2, 1, or 2 SECONDS
- USE FFT - DURATION 2^N SECONDS 512, 1024, 2048 ...
- LONG TERM D.F's SLOPE UP TO THE LEFT
- SHORT TERM D.F's SLOPE UP TO THE RIGHT

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PRACTICAL CONSIDERATIONS

- INSTRUMENTS MAY FAIL
- NOISE MAY BE RECORDED
- DATA EDITING NEEDED
- REDUNDANCY USEFUL
- SPECTRUM NOT EVERYTHING

Slide 4

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RECOMMENDED EXTENSIONS

- STATISTICAL MODEL FOR STRATIFIED (HIGH WAVE) SAMPLING NEEDED
- USEFULNESS FOR MOMENTS ABOVE VARIANCE SHOULD BE EVALUATED
- INDEPENDENT TESTING OF GAGE RESPONSE AND RELIABILITY NEEDED

Slide 5

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DEPARTMENT OF THE ARMY
COASTAL ENGINEERING RESEARCH CENTER
KINGMAN BUILDING
FORT BELVOIR, VIRGINIA 22060

CERRE-CO 2 November 1977

Mr. Orville T. Magoon
Chief, Coastal Engineering Branch
U.S. Army Engineer Division
South Pacific
630 Sansome Street
San Francisco, CA 94111

Dear Orville:

This letter is a response to the request from both you and Bob that I suggest ways in which CERC can contribute toward the success of the wave gaging program of SPD.

I shall begin by saying that I think data gathering programs of the type and scale you are proposing are necessary if the Corps need for wave information is ever to be satified. I believe that if such a program is to succeed initiative must be taken at Division or District level. CERC should be involved in planning but should not be dominant. CERC does not have the manpower to install and maintain an effective wave gaging program in California. Therefore, if the problem of organizing and managing such a study were assigned to us, it would be necessary to accomplish most of the work by contract as you are doing.

CERC started to collect wave data in the ocean before 1950. We have experience with almost every type of wave gage ever considered and with most proposed analysis systems. Because of this experience and the fact that several of us have been acquainted with most leaders in the development of wave gaging programs, wave prediction programs and wave theory for the past 10-20 years, I think that we are exceptionally well qualified to serve in an advisory or consultant capacity to evaluate and compare the trade-off's of various strategies for collecting the information needed by engineers. We have the competence to make the comparison, but we do not have the manpower required to participate in the basic program of data collection and analysis. Therefore, we cannot have a conflict of interest in presenting our advice. This could be important.

It should be recognized that no one strategy can provide the optimum solution of all wave data problems, and I certainly have not considered all important aspects of your program in the past week. Nevertheless

CERRE-CO 2 November 1977

Mr. Orville T. Magoon

I have listed five peripherical problems that need to be solved to obtain the most cost effective program. The first of these is an evaluation of the pressure sensor being used by Dr. Seymour. I believe that CERC can handle this one without reimbursement if you can obtain an instrument and signal conditioning equipment for us. The data processing part of the study can be accomplished by existing programs along with similar analysis from our own gages. The prototype for this test would be that described by Esteva and Harris (1970) Proceedings of the Coastal Engineering Research Conference.

The second program would be more difficult and would also build on work published recently by Dr. Esteva. This would not overlap scheduled work as much as the first problem and would require some new funding. I cannot estimate how much until I review the technical explanation of the longshore transport model promised to me at the meeting last week.

The third problem, dealing with extreme value statistics from gage records, would be the most interesting. I would like to do this, but I have no expectation of finding enough time. I hope that it can be contracted to Prof. Borgman or someone with his interests and background. CERC could handle the fifth problem expeditiously.

I cannot think of anyone better than Professor Thompson, NPGS, for the fourth problem. The principal investigator will need a background in meteorology and in dealing with coastal wave records. The work can furnish material for several theses and will not require extensive guidance from the principal investigator, but guidance in dealing with both meteorology and wave records is essential.

In Monterey on Friday, I saw breakers up to 10-12 feet high with periods of 18-24 seconds. The experience reinforced my interest in wave grouping and the California wave climate.

I enjoyed participation in your meeting last week, and I hope I can retain some involvement with your program.

Sincerely,

D. Lee Harris

D. LEE HARRIS

CERRE-CO 3 November 1977

SOME NEEDED RESEARCH AND DEVELOPMENT TO MAXIMIZE THE VALUE OF DATA OBTAINED IN THE WEST COAST WAVE DATA COLLECTION PROGRAM

1. INDEPENDENT EVALUATION AND CALIBRATION OF THE SCRIPPS PRESSURE SENSOR BEING PLANNED AS THE BASIC WAVE GAGE.

It is suspected that records from this gage will be adequate for most engineering applications, and that it will prove to be the most cost effective sensor available for the purpose. It is doubted that the in situ performance will match the one mm of sea level accuracy claimed. Independent evaluation and calibration are needed to establish the proper confidence level.

2. INDEPENDENT EVALUATION AND CALIBRATION OF THE DIRECTIONAL ARRAY CONCEPT USED FOR DETERMINING THE ALONGSHORE MOMENTUM TRANSPORT.

From the information available, it appears that this system should provide a reasonably accurate value of the alongshore momentum transport when only one wave train is available in each frequency band and the bottom contours are parallel to the beach for a sufficiently large region near the gage array. The accuracy of the determination of S_{xy} at the array, and the accuracy of the inferrence about sediment transport will decrease to an unknown degree as true conditions depart from the basic assumptions. It appears that this array will be a cost effective means of gathering information about alongshore momentum transport in many areas but not in all. The developer has presented some information which indicate the accuracy of the existing system is useful but not quite as good as he had expected.

3. DEVELOP A NON-RANDOM SAMPLING THEROM FOR THE DETERMINATION OF LONG TERM WAVE STATISTICS

Statistics on the frequency of occurrence of extremely severe wave conditions are needed for the design of various structures. The simplest definition of severe wave conditions is extreme wave height. It has been found by CERC that the frequency of occurrence expressed as a percentage of the time that wave heights exceed a specified value can be determined with acceptable accuracy from one observation per day for the lower 50-75% of all waves. With four observations per day, for a year, a satisfactory treatment is obtained for the lower 90-95% of all waves. The extreme waves of the year have a high probability of being missed with only four observations per day. Thus a better specification of the extreme waves and the duration of extreme waves would be possible, if wave conditions were recorded and analyzed continuously when wave heights are above some critical value. By the same token, a full analyses may not be needed for the lowest 25-50% of the recorded waves. Present technology permits the assembly of data recording and analyses systems, which vary the frequency of wave data recording and analyses procedures in response to ambient conditions. New statistical models are needed to exploit this capability in producing the most cost effective program for recording and analyzing wave data.

SOME NEEDED RESEARCH AND DEVELOPMENT TO MAXIMIZE THE VALUE OF DATA OBTAINED IN THE WEST COAST WAVE DATA COLLECTION PROGRAM

It should be recognized that wave parameters other than wave height may, and should, be considered in this manner; and that this procedure can not assure the development of adequate data for extra ordinary intense storm types which do not occur within the data collection periods, but it should lead to a reduction in operating costs of extended operation of a wave gaging system without significantly reducing the value of the data obtained with the system.

4. CASE STUDIES OF EXTREME WAVE CONDITIONS ARE NEEDED.

The most extreme wave events are generally associated with well developed storm systems. Case studies based on the compilation of all available wave observations and a comparison of the appropriate features of the synoptic weather charts for the period of wave generation will provide information about the meteorological causes of severe waves which will provide the basis of judgement about how long a wave record must be to provide reliable guidance about extreme events. Comparison of these case studiies based on observed waves with similar case studies based on hindcasts, will provide a useful tool for the evaluation of wave hindcasts.

5. DETERMINATION OF THE REQUIRED RESOLUTION OF THE WAVE GAGE RECORD.

It has been the custom at CERC to digitize analog signals from wave gages to a resolution of .00025 to .001, that is to a resolution of 10-12 bits in order to make certain that the accuracy of the instrument systems is never compromised by round-off error. SIO and other groups have been using the same standards, and the continuation of this standard was recommended by the task group because no one had information which would justify the acceptance of lower standards. With the equipment used by CERC in the past, and with at least some of the equipment used by SIO, the above standards were cost effective because the digitizers had sufficient accuracy and data were processed by 12 or 16 bit system or stored on tape, and no economy could be achieved by reducing the resolution. With the development of microprocessor technology, considerable savings would be achieved by accepting 8-bit accuracy, that is a resolution of one part in 254. This is a greater accuracy than many suppliers claim for their sensors. It should be noted that comparison of records from gages separated by distance of 6-33 meters frequently show differences in wave height of two percent, and occasionally show differences of 10 percent even when the data are collected with a resolution of 10-12 bits. It is possible that all of the available information can be obtained within an 8-bit data word.

With the development of a program involving 100 gages, this question merits serious attention.

DLH/fms

INCLOSURE 10

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SURVEY
Rockville, Md. 20852

C33x2E-200
WMP

October 13, 1977

Mr. Orville Magoon
Chief, Coastal Engineering Branch
South Pacific Division
Corps of Engineers
630 Sansome Street, Room 1212
San Francisco, California 94111

Dear Orville:

Enclosed is a brief description of our planned data collection and analysis methods for the initial phase of NOAA's Coastal Wave Monitoring Program. The first section of the description is from a talk that I am giving at the American Shore and Beach Preservation Association Annual Meeting, October 17-19.

I suggest that you keep written notes of major points during the work group discussion on October 27. I would very much like to receive a copy of these notes so that we may use them in further planning for our program. NOAA's full-scale wave program is scheduled for implementation in Fiscal Years 1979-1983 provided that our budget is approved by OMB and Congress. Thus, in specifying our ultimate data collection and analysis procedures we have an opportunity to consider recommendations from your meeting and from your ASCE Task Committee on Ocean Wave Statistics. I would also appreciate future assistance in obtaining suitable analysis computer programs. Of course, any procedures or programs that we develop will be available for others to use.

I am most sorry that the time of the October meeting does not fit into my schedule. Please advise me well ahead of time about follow-on meetings so that I can attend. It is very important that our programs be coordinated.

Sincerely,

Marshall

Marshall D. Earle
Special Assistant
Oceanographic Division

Enclosure

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

NOAA

Incl 10

NOAA'S COASTAL WAVE MONITORING PROGRAM*

General Plan

This spring (1977) NOAA's National Ocean Survey began a Coastal Wave Monitoring Program to remedy our present inadequate knowledge of wave conditions for application to engineering, scientific, and environmental projects. Major applications for data and products from this program are listed in Table I.

A major part of the Coastal Wave Monitoring Program is the Ocean Wave Climate Symposium which was held on July 12-14, 1977. This National Ocean Survey sponsored symposium was oriented toward providing input for planning the Coastal Wave Monitoring Program. It was attended by invited experts representing a broad spectrum of coastal and ocean engineering wave data users, scientific wave data users, developers of wave measurement systems, and government agencies with missions that require wave data. User requirements, wave measurement instrumentation, and wave forecasting and hindcasting methods were discussed in working groups which presented recommendations for the Coastal Wave Monitoring Program.

The three primary data acquisition requirements for the wave monitoring program are: (1) the program must have comprehensive geographical coverage; (2) the measured wave data must be suitable for analysis to determine wave frequencies and directions; and (3) long-term wave conditions must be monitored. To satisfy these requirements, an operational measurement program consisting of a primary network of outer continental

*Prepared by M. Earle, Oct. 13, 1977.

shelf wave measurement systems and a portable secondary network of nearshore wave measurement systems is presently planned. A detailed study by geographical area, of synoptic meteorological conditions, storm characteristics, storm and hurricane occurrence frequencies, available wave data, wave hindcasts and immediate needs for wave data will determine the actual locations of the primary network wave measurement systems. Geographic coverage will encompass coastlines of the continental United States, including the Great Lakes, and coastlines of Alaska and Hawaii. The secondary network, which will be moved systematically from one region to another, will provide short-term measurements to determine correction factors for determining long-term nearshore wave conditions at many locations based on the measured offshore wave conditions.

The use of a limited number of relatively deep water measurement sites for long-term wave measurements combined with short-term nearshore measurements is the most cost-effective means to obtain knowledge of nearshore wave conditions at many locations. As waves progress from deep water toward shore, wave characteristics are significantly modified due to shallow water effects. Because these effects depend on the local bottom topography and coastline configuration, which vary from one location to another, wave measurements near or at the coastline represent wave conditions only in the immediate vicinity of the measurement site. An extraordinary number of neashore sites, on the order of hundreds, would be needed to obtain comprehensive geographical coverage. On the other hand, measurements of offshore wave conditions coupled with

computer models using the known bottom topography can provide nearshore wave conditions at many locations. Short-term nearshore measurements are required to verify and calibrate the computer models for long-term use.

A number of wave measurement systems are being evaluated for use by the Coastal Wave Monitoring Program. These systems include accelerometer buoys, shore-based radar, instrumented offshore platforms, and bottom mounted pressure and acoustic sensors for shallow water use. To take advantage of local situations such as offshore structure availability, a mix of measurement systems may be used. In addition, satellite remote sensing techniques (SEASAT-A radar altimeter measurements) will be examined for eventual incorporation into the operational program.

In 1977 and 1978, the Coastal Wave Monitoring Program is being operated on a small scale with funds redirected from other NOAA projects. These efforts are concentrating on evaluation of wave monitoring systems, plans for development of shore-based radar wave measurement systems, studies of user requirements for data and analysis products, development of wind and wave hindcast methods to be calibrated with the collected wave data, and the establishment of procedures to provide real-time wave data to marine forecasters. Wave monitoring will begin in 1978 off the Atlantic Coast. Present plans call for instrumenting an unmanned U.S. Navy fixed platform off Cape Hatteras and installing small "waverider" type accelerometer buoys shoreward of Baltimore Canyon. The offshore platform measurements, which are a joint Navy-NOAA effort, will include wave heights at three

points so that directional energy spectra can be estimated, wind speed and direction, and platform strains and accelerations. Data from the platform and buoys will be telemetered to shore and will then be transmitted via phone line in real-time to National Ocean Survey headquarters in Rockville, Maryland.

Implementation of the fully operational Coastal Wave Monitoring Program is planned for 1979 through 1983. Funds for the full-scale program are not yet available and NOAA is attempting to obtain a budget increase to cover the 1979 through 1983 time period. The wave program is two-phased in terms of wave measurement systems for the primary network. An offshore platform and accelerometer buoys will be utilized in 1978 and additional platforms and buoys will be used at other locations beginning in 1979. These measurement systems will mainly provide wave energy frequency spectra and, at some locations, estimates of wave energy directional spectra. While these measurements are made, the Coastal Wave Monitoring Program will be funding the development of better wave monitoring systems including shore-based radar. As updated measurement systems are proved suitable for the wave program, simple accelerometer buoys may be gradually phased out. Under the program plan, the operational systems in use after 1983 will consist of advanced measurement systems capable of monitoring wave energy directional spectra.

Sampling Strategy

Under normal conditions, wave records of approximately 20 minute length will be recorded in real-time at 3 hour intervals. The sampling rate within each record will be either 0.25 second or 0.50 second. During data processing, fast Fourier transform computer routines will be used so that record lengths will be either 2048 or 4096 data points.

At each wave measurement location, data will be monitored at an hourly interval for a time period of about 5 minutes and an estimate of the mean wave height will be computed in real-time by the zero crossing method. If the mean wave height exceeds a predetermined threshold value, which can change with measurement location, digitized data will be recorded. Subsequent mean wave height determinations will be based on 20 minute record lengths. When the mean wave height falls below the threshold value at a location, recording will cease and data collection will proceed as under normal conditions. By manual intervention at the central recording site in Rockville, Maryland, digitized data of any record length can be recorded for any measurement location. Automatic threshold recording allows the collection of data during occurrences of high waves at each measurement site. Manual intervention allows the collection of data for specific events such as scientific experiments utilizing the wave data.

The extent of simultaneous recording of wave data from different measurement locations will be influenced by hardware and software considerations for the central recording system. There will be a limit to the number

of stations from which data can be simultaneously recorded and priority criteria, based on wave height or station location, may be programmed to control automatic threshold recording. The extent of simultaneous recording will be addressed as our overall system design proceeds.

Analysis of Individual Records

As data is recorded in real-time, mean wave heights, maximum wave heights, and mean wave periods will be computed by the zero crossing method. These results will be available at the central recording site and can be provided to users. Digitized wave data, with appropriate identifying headers including time and station location, will be recorded on magnetic tape. Although some data processing can occur at the central recording site, the standard procedure will be to analyze full data tapes on a large NOAA computer which is being procured and which will be installed in the same building as the central recording site.

For each individual record, a wave energy frequency spectrum will be calculated and wave heights and periods will be determined by the zero crossing method. From the spectrum, the following results will be recorded on magnetic tape: wave energy in discrete frequency bands, significant wave height, period of maximum wave energy, and an estimate of the spectral width. From the zero-crossing analysis, the following results will be recorded on the same magnetic tape: significant wave height, significant wave period, maximum wave height and associated wave period, mean wave height, mean wave period, and the joint probability distribution of wave

heights and periods. Copies of this analysis tape and the digitized data tape will be provided to the National Oceanographic Data Center for archival. For our program, it is important that the original data be retained for subsequent special analysis either by NOAA or outside users of the data.

Directional data from the offshore platform will be analyzed separately on an experimental basis until operational procedures are selected. However, wave height data from one of the wave staffs on this platform will be analyzed in the same manner as wave height data from other locations.

Analysis of Long-Term Data

From the analysis tape described above, the following statistics will be determined on a monthly and/or seasonal basis: probability distributions of significant wave heights, probability distributions of mean wave periods (or periods associated with maximum wave energy), joint probability distributions of significant wave height and significant wave period as calculated from zero crossings, and wave persistence. The wave persistence results will provide the number of occurrences, the maximum occurrence length, and the mean occurrence length for significant wave heights greater than and less than specified values. Consideration will be given to calculating an average wave energy frequency spectrum and an average wave height and period joint probability distribution for typical day-to-day conditions, winter storm conditions, and hurricane conditions. These long-term analysis results will be provided in data reports. Included in these reports will be descriptions of wave conditions during specific

events such as storms and hurricanes. In addition to providing information suitable for many users these reports will serve as a guide to the archived wave data and analysis results.

Status of Analysis Programs

The Coastal Wave Monitoring Program does not presently have documented analysis programs available. Suitable programs will be obtained from other organizations, undocumented programs that have been written by M. Earle will be modified, and new programs will be written in-house and by contractors. Error checking and data editing programs must be written. Whenever possible, the wave program would make use of existing programs that are efficient and correctly perform the needed analyses.

TABLE I

MAJOR APPLICATIONS FOR NOAA'S COASTAL WAVE MONITORING PROGRAM

OCEAN ENGINEERING DESIGN

BEACH EROSION PREVENTION

- BREAKWATERS
- BULKHEADS AND SEAWALLS
- GROINS

COASTAL PROCESSES MODELS
HARBORS INCLUDING BREAKWATERS
NAVIGATION CHANNELS INCLUDING JETTIES
OFFSHORE STRUCTURES
SAFETY REGULATIONS
SUBMARINE PIPELINES
WAVE HINDCASTING

MARINE OPERATIONS

DREDGING

- BEACH NOURISHMENT
- HARBOR AND CHANNEL MAINTENANCE

OFFSHORE AND COASTAL CONSTRUCTION
POLLUTANT CLEANUP
SAFETY REGULATIONS
SEARCH AND RESCUE MISSIONS
VESSEL AND EQUIPMENT SELECTION
WAVE FORECASTING

INCLOSURE 11

NATIONAL OCEANOGRAPHIC DATA CENTER
WAVE ARCHIVING
BY
MR. WELLINGTON WATERS, SR.

The NODC is a major component of the Environmental Data Services (EDS). EDS is a Principle Organization Element (POE) of the National Oceanic and Atmospheric Administration (NOAA) which came into being in about 1971. The EDS is the first agency created specifically to manage environmental data. It disseminates worldwide environmental data and information for use by commerce, industry, the scientific and engineering community, the general public as well as Federal, State and local governments. Data involved are aeronomy, atmospheric, marine, solar and solid earth data and information. It provides experiment design to large-scale environmental experiments, and provides data management support to these experiments. EDS assesses the impact of environmental fluctuations on food production, energy production and consumption, and environmental quality.

EDS operates related World Data Center - A sub-data centers which manage international data and information exchange.

The EDS is comprised of six major organization components. They are: (1) The National Climatic Center (NCC), (2) The National Geophysical and Solar-Terrestrial Data Center NGSDC), (3) The Center for Experimental Design and Data Analysis (CEDDA), (4) The Environmental Science Information Center (ESIC), (5) The Center For Climatic and Environmental Assessment (CCEA) and (6) The National Oceanographic Data Center (NODC).

Headquarters of the EDS and most of its major components are in the Washington, D. C. Area. Headquarters for NCC is in Ashville, North Carolina; for NGSDC in Boulder, Colorado, and CCEA in Columbia, Montana.

The NODC was the first NODC established in the world and houses the world's largest useable collection of marine data. These data presently consist of (1) mechanical and expendable bathythermograph data, (2) the conventional oceanographic station data, (3) the newer salinity-temperature-depth data, (4) surface current data obtained by drift devices and ship's drift calculations and (5) various biological data.

The NODC has developed standardized formats for most of these types of data. In some cases, this has been relatively simple because the means of collecting, processing, and analyzing these data have, down through the decades, been themselves standardized. In other areas (such as in current data and wave data and chemical data) there does not yet seem to have developed large-scale agreement on data collection and processing as with some of the more conventional data disciplines.

Incl 11

Where does NODC stand on wave data?

First, the NODC was declared the lead organization within EDS to develope a data storage and retrieval system for instrument measured wave data. NCC is to retain the responsibility of the storage of visual observations and their file of visual world observations numbers almost in the tens of millions. They do not represent exteme conditions since they were mostly obtained under restricted conditions.

The NODC has on file some measured wave data. Most of these data are from the National Data Buoy Office. Processing of these data, regardless of source, has been aimed towards being able to retrieve the data in essentially the originators format. One important part of this type of processing is the collection of documentation on the collection and processing of these data and making this documentation available to users along with the data. So we do not at this time have a standardized format or real standard procedures for processing wave data. We are, however, trying to develop one at this time.

We have been involved in this development effort since about January 1977. We have started from about ground zero. Up to this point our major efforts have been directed towards collecting background information on instrumentation, reasons for a national wave measuring program, studies of collection, processing, and analysis programs already in existence both nationally and internationally. We have produced several reports primarily for inhouse use on what we have learned.

We were told early in our research that Canada's Marine Environmental Services had operated a wave data system over the last 8-9 years and that their system was highly respected internationally.

So, over the last 7-8 months, besides our general background information study, I would say our major accomplishments have been reports on the Canadian MEDS wave data system, a letter poll of suggestions and needs of our secondary users and recently, the generation of a systems development proposal which is to be presented and discussed at an EDS retreat which will take place in November 1977.

What are we proposing?

Basically we are proposing that EDS store raw wave data which has been quality edited to the extent possible and practical. Also we will store processed data which include calculations of the usual statistical parameters-significant wave height, peak period, various spectra data on height, period, and direction when available. We are proposing, initially or in Phase I of our development, routine outputs of MEDS type products including (1) scatter diagrams showing frequency of occurrence of various period - height combinations; (2) peak period histograms; (3) wave height versus time plots; (4) listings of spectra density or equivalent wave height versus frequency or wave period classes; (5) percent exceedance diagrams of wave height. We will also output some persistance product. We have learned some things but realize there is much yet we need to learn. We will continue to study systems operated nationally and internationally hopefully to design at least a near optimum system.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL DATA SERVICE
Washington, D.C. 20235
National Oceanographic Data Center

November 3, 1977

Mr. Orville Magoon
Department of the Army
South Pacific Division Corps
of Engineers
630 Sansome Street, Room 1216
San Francisco, California 94111

Dear Orville:

I enjoyed attending your wave conference and learned quite a few things about the Corps' wave program. I am anxiously awaiting information as to the final decisions and recommendations resulting from the meeting.

Enclosed are copies of some letters we received which I promised to send you and my review of Canada's MEDS wave data system which Bob Edmisten requested. I hope these are useful to the Corps.

Again, thanks for the invitation to attend your conference and your kind offer of full cooperation. I will keep you and others of the Corps informed as we progress with the development of our system - hopefully, at least, at major milestones of its development.

Best Regards,

Welly

Wellington Waters, Sr.
Oceanographer
Data Systems Formulation
and Integration Branch

Enclosures (5)

cc: N. Ross, West Coast Liaison Officer

Chevron

Chevron Oil Field Research Company
A Standard Oil Company of California Subsidiary
P.O. Box 446, La Habra, CA 90631, U.S.A.

June 30, 1977

Mr. Wellington Waters, Oceanographer
Data Systems Formulation and Integration Branch
National Oceanographic Data Center
Environmental Data Service
National Oceanic and Atmospheric Administration
Washington, D.C. 20235

Re Your Ref D752/WW

Dear Mr. Waters:

In response to your letter of May 24, 1977, we are pleased to have the opportunity to suggest wave data parameter formats and presentations we have found useful. We have had considerable experience with wave data measured by ourselves and others and consequently have dealt with wave formats in working situations.

We are generally interested in two types of wave information (1) normal conditions--climatological summaries of the wave conditions on a monthly or seasonal basis to be used in planning offshore operations; and (2) extreme conditions--detailed descriptions of rare, severe events used to aid us in determining design criteria for offshore facilities. We prefer wave data measured in deep water (greater than 300 ft) so transformation can be made to a nearby or shallower location. The preferable data type would be directional wave spectra; however, we recognize that obtaining directional spectra is generally too expensive for most wave measurement systems. Not for USA

Regarding your request for our comments regarding the routine outputs of the Canadian Marine Environmental Data Service (MEDS), we have examined the MEDS outputs as described in their "Summary of Available Wave Data Products". Comments on each specific output are presented in the attached "Review of Wave Data Presentation Formats". Basically the MEDS seems to be a good model upon which to base your formats, although we suggest a few additions that would make these outputs more useful.

The attached Review also suggests some additional wave data presentations not covered in the MEDS output. These presentations are (1) information on persistence of favorable and unfavorable wave conditions, (2) summaries of month-to-month averages of conditions, and (3) listings of extreme events.

Incl 1 to 3 Nov 77 Letter

Our preference of output media would be both hard copy and magnetic tape. For most normal wave information the hard copy would be adequate. For extreme events detailed analyses of storms and individual waves in storms would require wave data on magnetic tape.

In addition to the obvious information on wave sensor type, period of observations, location, etc., the method of analysis of wave data, including the definitions of wave heights and periods, should be included as a descriptor of wave data. Comments on wave data analysis are included in the attachment.

We hope our comments will be useful to you. If you have additional questions or suggestions or would like to discuss these matters further, please contact Mr. Anthony Fallon (213-691-2241).

Very truly yours,

L. W. Thrasher

L. W. Thrasher, Vice President
Production Research Department

Attach: Review of Wave Data Presentation Formats

REVIEW OF WAVE DATA PRESENTATION FORMATS

INTRODUCTION

In response to a request from the National Oceanographic Data Center (letter, W. Waters-L. W. Thrasher, 5-24-77) for comments on these particular formats, this review of wave data is directed to the "Summary of Available Wave Data Products" published by the Marine Environmental Data Service (MEDS) of Environment Canada. The MEDS Data Product Descriptions are attached to these comments.

COMMENTS ON CANADA'S MEDS WAVE OUTPUTS

1. Exceedance diagram. This is a useful diagram and should be presented on a monthly or seasonal basis, rather than yearly or over an arbitrary data collection period, to describe normal wave conditions.

   The maximum wave height should not be presented on this diagram unless it is the actual measured maximum wave height during the sampling interval rather than the theoretical maximum wave height as described in the MEDS summary. The fact that the significant wave height is based on the RMS of the water surface fluctuations should be so noted on the figure itself and if maximum height is retained, it should be clearly identified as theoretical maximum on the figure. A linear scale for wave height might be preferable to the log scale of the MEDS to facilitate interpolation of values on the curve.

2. Wave height listing. This format presents spectral wave information in a computer listing (we would prefer spectral energy density rather than "equivalent wave height"). These data would be useful for periods of storms or high wave conditions and would be primarily of interest to aid in our extreme wave height analyses. This is a good format in which to store data but probably not as routine output for all periods.

   Several formats for presenting a quick visual summary of this type information should be considered. Attached are samples of the time history spectral output of the NOAA Data Buoy Office (Figure 1) and the California Department of Navigation and Ocean Development (Figure 2) for consideration.

3. Significant wave height versus time plot. This is a very good and useful format. From this plot one can tell at a glance when interesting segments (storms) occur and when data gaps exist.

4. Scatter diagram. This diagram should be presented on a monthly and/or seasonal basis. This diagram would be much more useful with the addition of totals by columns (period) and rows (height). An additional cumulative total for wave height in this diagram would also be a useful addition.

   As an alternative to the scatter diagram of MEDS a frequency-of-occurrence table of wave height versus period might be used, as shown in the example (Figure 3).

5. Peak period histogram. We do not generally use such totals of wave period independent of wave height. The information presented in this histogram would be redundant with the totals from the period column in the scatter diagram if the suggestion from #4 above is taken.

6. Spectrum diagram. The spectrum diagram would be most useful during storm events. There is also some application of the spectra during normal conditions, for analyses of vessel response, but this wave data should be treated as a special request and not as standard output. The spectra might be used for determining extreme conditions by calibrating hindcast models or scaling up the spectra measured during severe storms to a "design storm".

7. Surface elevation trace. The surface elevation trace would be useful for looking at individual waves during a severe event. This product would be helpful for determining extreme conditions and need not be a routine normal product output.

ADDITIONAL WAVE DATA FORMATS

The following wave data products have been found to be useful and are not specifically covered in the routine MEDS outputs.

* 1. Persistence of favorable and unfavorable conditions. When planning operations it is often quite important to know the expected duration of storm conditions exceeding a given wave height or expected duration of calm conditions less than a specific wave height. In Figure 4 is presented an example of a table of persistence wave data. To be useful such a table requires more than a few events and, thus, monthly summaries (unless many years of data are combined for a given month) are generally not adequate and seasonal summaries or even yearly summaries should be used.

2. Month-to-month averages. Tables or plots of wave parameters by month can be quite useful in planning operations and deciding in which months one should begin or suspend operations Figure 5 and 6 present examples of presentations of such data that have been useful.

3. Listings of extremes. If possible, the maximum wave height recorded during each segment should be measured by some consistent method, for example, trough to following crest. It is very important for developing extreme wave height climatology that a continuous record be made of all waves above a given threshold rather than, for example, a 20 minute record every 3 hours. The threshold should probably be set depending upon the wave climate so that continuous recording would be made when the significant wave height was above a relatively rare level. Special "storm reports" could then be presented for each of these events and could include products such as the MEDS wave height listing, spectrum diagrams, and surface elevation traces. *

COMMENTS ON WAVE DATA ANALYSIS

Individual Wave Height

The definition of individual wave heights needs to be clearly defined in a presentation of wave data. For example, wave height can be defined as difference between (1) crest to preceeding trough, (2) crest to following trough, or (3) crest to average of preceeding and following trough. Differences in wave statistics would be expected using these different definitions of wave height and it is most important to state the method used and to use the same method consistently.

Significant Wave Height

The often-used descriptor of sea state, "significant wave height", can be misleading unless the method of analysis is defined. For example, significant wave height could be: (1) four times the RMS of the water surface fluctuations; (2) the average of the highest one-third of the wave heights in a sample; (3) the Tucker-Draper significant wave height based on a theoretical relationship with either one or two largest crests and troughs in a sample; or (4) a visual estimate. If water surface profile data is being computer processed in digital form either method (1) or (2) should be used to determine significant wave height and

why?

preferably both. Method (3) is a short-cut technique primarily useful for hand-analysis of strip-chart records. All output should clearly describe the significant wave height method used.

Wave Period

Wave period is often presented as: (1) average zero-crossing period of all waves in a sample; (2) dominant spectral period or the period of maximum energy in the wave spectrum; or (3) significant period or average period of the one-third highest waves. The zero-crossing period results are needed for such analyses as fatigue studies and for extreme analyses requiring the number of waves in a sample. Theoretical relationships may be used to relate the different wave period definitions but these are usually dependent upon the spectral characteristics. ?

Attach: MEDS Product Descriptions
Figures 1-6

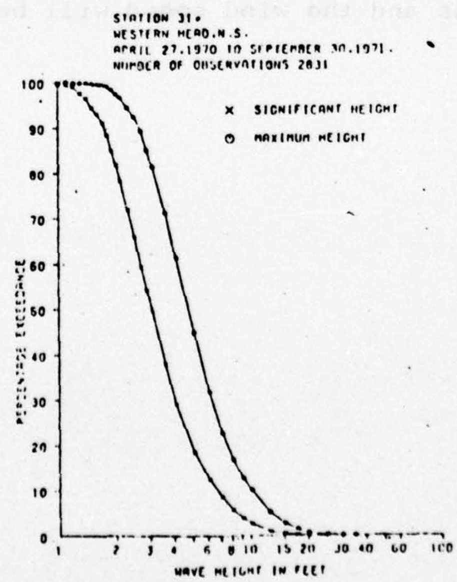
Data Product Description

(1) Exceedence Diagram

This diagram shows the observed percentage of the wave records for which the significant wave height exceeded a certain value. The significant wave height for each wave record was computed as four times the square root of the area under the variance spectrum of the water surface elevation.

The curve labelled maximum should be interpreted as the exceedence curve for the most probable maximum wave in a twenty-minute period. This wave was computed using the Longuet-Higgins (1952) theory for the statistical distribution of the heights of sea waves for a narrow band of frequencies. The most probable maximum wave is, according to this theory, derivable from the significant wave height and the number of waves in the record. The number of waves was obtained by dividing the length of the record time (twenty minutes) by the peak period of the spectrum. The peak period for each wave record is defined as the inverse of the frequency at which the maximum spectral density occurred.

The period of time over which the observations were made is annotated at the top of the diagram. The number of observations from which the histogram was prepared is also annotated.



Longuet-Higgins, M.S. 1952, Journal of Marine Research, XI, No. 3, 245.

Data Product Description

Wave Height Listing

This computer listing has one line of print for each 20 minute wave record. The record, side and analog recording tape number and the time of the record is shown. The time is local standard or local daylight saving time, whichever is in effect locally.

The columns headed 2 to 3 sec., 3 to 4 sec. et show "equivalent" wave heights in feet obtained by integ under the variance spectrum of the water surface elevati to find the area between frequencies corresponding to the two periods appearing at the top of the column. The equivalent wave height is equal to the square root of thi area multiplied by $2\sqrt{2}$.

The value in the column headed 2 to 20 seconds when multiplied by a further $\sqrt{2}$ is the significant or characteristic wave height. The column headed "wave ergy" is the energy in feet squared obtained between frequencies of 0.05 and 0.5 Hz.

The column headed "peak per." is the inverse of the frequency at which the maximum spectral density occurred.

If the wind speed and direction is included with the wave data, this will appear as two final columns on the listing. The wind direction will be in either 8 or 16 poin of the compass and the wind speed will be given in miles pe hour.

(2) EQUIVALENT WAVE HEIGHT TABULATED BY WAVE PERIOD

RECORD -SIDE -TAPE	MAY 1970 HOUR	DAY	2.0 TO 3.0 SEC	3.0 TO 4.0 SEC	4.0 TO 5.0 SEC	5.0 TO 6.0 SEC	6.0 TO 7.0 SEC	7.0 TO 8.0 SEC	8.0 TO 9.0 SEC	9.0 TO 10.0 SEC	10.0 TO 11.0 SEC	11.0 TO 12.0 SEC	12.0 TO 13.0 SEC	13.0 TO 14.0 SEC	14.0 TO 15.0 SEC	15.0 TO 16.0 SEC	16.0 TO 20.0 SEC	2.0 TO 20.0 SEC	WAVE ERGY FEET SQR.	PEAK PER. SEC.	WIND VEL. MPH.	WIND DIR.
5-1-3	200	7	0.44	0.66	0.81	0.93	1.06	1.08	1.15	0.93	0.56	0.29	0.17	0.18	0.13	0.09	0.11	2.69	0.90	8.03	3	SW
6-1-3	500	7	0.42	0.59	0.56	0.90	1.05	0.87	0.98	0.87	0.41	0.24	0.14	0.17	0.12	0.09	0.10	2.37	0.70	9.10	10	S
7-1-3	800	7	0.57	0.49	0.63	0.86	0.74	0.64	1.09	0.89	0.35	0.20	0.19	0.14	0.10	0.07	0.10	2.30	0.66	9.10	12	S
8-1-3	1100	7	0.57	0.80	0.61	0.86	0.75	0.84	0.94	0.80	0.46	0.26	0.18	0.15	0.11	0.08	0.15	2.33	0.68	9.10	13	S
9-1-3	1400	7	0.93	1.21	1.28	1.05	0.79	0.83	1.03	1.00	0.64	0.29	0.22	0.16	0.12	0.09	0.16	3.01	1.13	9.75	25	S
10-1-3	1700	7	0.84	1.03	1.27	1.29	0.95	1.00	1.34	1.16	0.46	0.30	0.14	0.18	0.13	0.09	0.17	3.25	1.32	9.10	17	SW
11-1-3	2000	7	0.79	1.04	1.25	1.22	0.84	0.88	1.53	0.94	0.42	0.25	0.13	0.10	0.08	0.06	0.13	3.13	1.22	8.53	15	S
12-1-3	2300	7	0.72	0.87	0.89	0.92	1.13	1.09	1.35	0.90	0.43	[illegible]	0.21	0.13	0.10	0.02	0.13	2.90	1.05	8.53	16	S
13-1-3	200	8	0.81	0.97	1.06	0.97	0.94	0.78	0.82	0.77	0.52	0.23	0.17	0.15	0.10	0.06	0.11	[illegible]	0.85	5.10	14	S
14-1-3	500	8	0.72	0.89	0.87	0.85	0.66	0.62	0.82	0.75	0.41	0.20	0.11	0.09	0.09	0.06	0.12	2.39	0.71	9.10	10	SW
15-1-3	800	8	0.55	0.77	1.02	1.14	0.96	0.90	0.93	0.71	0.35	0.19	0.14	0.10	0.08	0.07	0.10	2.55	0.81	8.03	11	S
16-1-3	1100	8	0.66	0.76	0.84	0.75	0.85	0.84	0.87	0.69	0.34	0.16	0.14	0.08	0.07	0.06	0.08	2.27	0.64	8.03	14	S
17-1-3	1400	8	0.86	1.13	1.11	0.86	0.97	0.82	0.97	0.74	0.43	0.26	0.16	0.10	0.09	0.08	0.12	2.72	0.52	8.53	24	S
18-1-3	1700	8	0.91	1.00	1.20	1.04	0.82	0.97	0.98	0.62	0.57	0.35	0.20	0.13	0.09	0.06	0.12	2.80	0.98	8.03	17	W
19-1-3	2000	8	0.67	0.86	1.09	0.90	0.66	0.93	1.08	1.09	0.60	0.26	0.21	0.09	0.10	0.10	0.14	2.77	0.96	9.10	10	S
20-1-3	2300	8	0.77	0.91	1.02	0.63	0.86	0,86	1.04	0.64	0.47	0.30	0.16	0.09	0.08	0.08	0.10	2.49	0.77	8.53	11	S
21-1-3	200	9	0.74	0.84	0.73	0.65	0.63	1.05	0.99	0.78	0.58	0.23	0.11	0.09	0.09	0.08	0.10	2.40	0.72	8.53	10	S
22-1-3	500	9	0.57	0.63	0.93	0.83	0.75	1.00	0.83	0.79	0.33	0.17	0.09	0.10	0.08	0.07	0.10	2.33	0.68	9.10	7	S
23-1-3	800	9	0.54	0.65	0.84	0.91	0.67	0.85	0.90	0.68	0.33	0.19	0.10	0.08	0.07	0.07	0.10	2.22	0.61	8.03	7	S
24-1-3	1100	9	0.52	0.57	0.74	0.84	0.74	0.81	0.86	0.62	0.33	0.16	0.12	0.07	0.06	0.06	0.12	2.09	0.55	8.53	16	W
25-1-3	1400	9	0.55	0.68	0.73	0.69	0.90	0.77	0.81	0.43	0.27	0.16	0.13	0.10	0.07	0.04	0.10	2.04	0.52	8.03	14	NW
26-1-3	1700	9	0.43	0.61	0.67	0.80	0.74	0.85	0.71	0.86	0.28	0.11	0.08	0.08	0.08	0.08	0.12	1.94	0.47	7.59	13	NW
27-1-3	2000	9	0.44	0.61	0.80	0.69	0.82	0.93	0.64	0.44	0.26	0.13	0.14	0.09	0.07	0.06	0.11	1.99	0.49	7.59	8	W
28-1-3	2300	9	0.43	0.53	0.65	0.73	0.60	0.75	0.60	0.35	0.26	0.16	0.13	0.12	0.09	0.07	0.11	1.73	0.37	8.03	3	N
29-1-3	200	10	0.35	0.37	0.49	0.65	0.84	0.73	0.59	0.35	0.25	0.17	0.10	0.05	0.05	0.05	0.10	1.66	0.35	6.50	3	S
1-2-3	500	10	0.27	0.36	0.42	0.68	0.87	0.78	0.58	0.54	0.32	0.10	0.11	0.07	0.08	0.09	0.11	1.73	0.37	5.63	7	S
2-2-3	800	10	0.29	0.39	0.53	0.62	0.68	0.63	0.75	0.50	0.29	0.19	0.12	0.12	0.09	0.08	0.11	1.65	0.34	8.53	3	S
3-2-3	1100	10	0.27	0.29	0.40	0.52	0.60	0.81	1.02	0.57	0.22	0.14	0.12	0.12	0.10	0.08	0.10	1.77	0.39	8.53	5	S
4-2-3	1400	10	0.23	0.32	0.43	0.50	0.65	1.10	0.91	0.42	0.25	0.20	0.12	0.08	0.11	0.12	0.13	1.85	0.43	7.59	6	S
5-2-3	1700	10	0.55	0.82	0.52	0.55	0.65	0.94	1.00	0.36	0.29	0.18	0.14	0.10	0.09	0.09	0.11	2.04	0.52	8.03	3	S
6-2-3	2000	10	0.49	0.82	0.75	0.62	0.87	0.87	1.00	0.60	0.24	0.20	0.11	0.15	0.11	0.09	0.11	2.71	0.61	8.53	6	S
7-2-3	2300	10	0.43	0.60	0.72	0.68	0.70	1.07	0.84	0.42	0.21	0.08	0.09	0.12	0.11	0.11	0.11	2.09	0.52	7.59	7	S
8-2-3	200	11	0.41	0.57	0.66	0.63	0.99	0.94	0.76	0.43	0.24	0.13	0.12	0.12	0.10	0.09	0.11	2.02	0.51	8.03	12	S
9-2-3	500	11	0.52	0.65	0.69	0.65	0.79	1.10	0.82	0.45	0.21	0.16	0.10	0.14	0.11	0.08	0.09	2.11	0.56	8.03	8	S
10-2-3	800	11	0.62	0.70	0.67	0.62	0.70	0.91	0.70	0.40	0.20	0.12	0.11	0.10	0.11	0.11	0.10	1.95	0.47	7.19	7	SW
11-2-3	1100	11	0.56	0.61	0.89	0.63	0.67	0.79	0.59	0.42	0.26	0.13	0.11	0.12	0.10	0.09	0.09	1.90	0.45	7.19	8	S
12-2-3	1400	11	0.54	0.57	0.72	0.84	0.91	0.80	0.58	0.31	0.19	0.17	0.09	0.10	0.09	0.09	0.14	1.97	0.46	6.83	3	SW
13-2-3	1700	11	0.43	0.64	0.72	0.84	0.77	0.71	0.58	0.29	0.21	0.13	0.09	0.09	0.09	0.09	0.09	1.86	0.43	8.03	5	E
14-2-3	2000	11	0.37	0.52	0.71	0.77	0.79	0.68	0.48	0.29	0.14	0.15	0.10	0.07	0.09	0.10	0.10	1.73	0.37	8.03	5	N
15-2-3	2300	11	0.33	0.45	0.51	0.71	0.74	0.86	0.50	0.30	0.16	0.14	0.08	0.10	0.10	0.09	0.13	1.71	0.36	7.19	6	N
16-2-3	200	12	0.30	0.39	0.55	0.65	0.69	0.78	0.42	0.22	0.16	0.10	0.08	0.12	0.10	0.09	0.09	1.53	0.29	7.19	3	E
17-2-3	500	12	0.31	0.39	0.60	0.75	0.77	0.75	0.50	0.22	0.15	0.14	0.10	0.10	0.08	0.07	0.10	1.64	0.34	7.19	7	N
18-2-3	800	12	0.36	0.40	0.58	0.74	0.66	0.78	0.45	0.27	0.16	0.10	0.10	0.09	0.08	0.07	0.08	1.60	0.32	7.19	8	N
19-2-3	1100	12	0.39	0.34	0.42	0.60	0.69	0.63	0.47	0.27	0.18	0.12	0.10	0.10	0.09	0.09	0.10	1.63	0.26	6.50	8	E
20-2-3	1400	12	0.23	0.36	0.43	0.48	0.55	0.67	0.42	0.18	0.16	0.11	0.08	0.12	0.10	0.09	0.11	1.36	0.23	7.59	5	S
21-2-3	1700	12	0.23	0.44	0.49	0.64	0.62	0.54	0.32	0.22	0.14	0.12	0.11	0.09	0.08	0.07	0.11	1.38	0.24	7.19	3	S
22-2-3	2000	12	0.36	0.42	0.47	0.63	0.65	0.58	0.45	0.26	0.12	0.10	0.09	0.11	0.10	0.09	0.09	1.42	0.25	7.59	4	E
23-2-3	2300	12	0.30	0.37	0.39	0.55	0.51	0.57	0.48	0.24	0.19	0.12	0.13	0.15	0.11	0.08	0.10	1.29	0.21	8.53	4	E

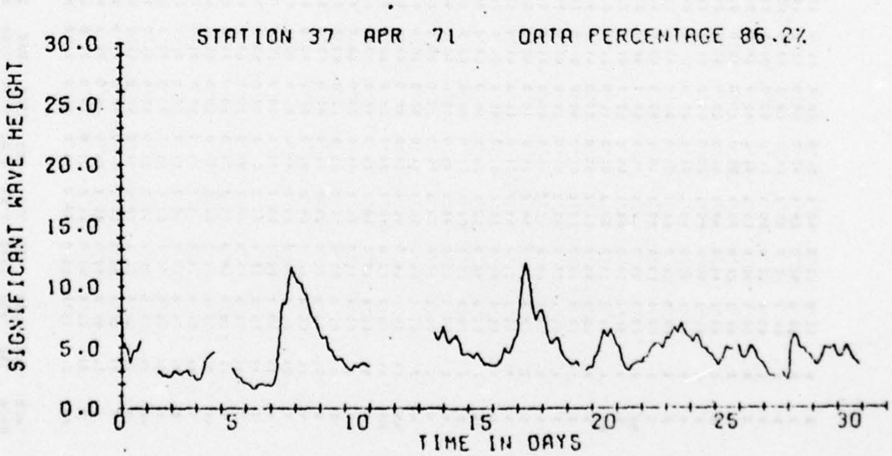
Data Product Description

(3) Significant Wave Height vs Time Plot

This graph shows the value of the observed significant wave height plotted against time for a month. The significant wave height has been computed for a 20 minute wave record every three hours. It is defined as four times the square root of the area under the variance spectrum of the water surface elevation. The units are feet.

When the interval between successive wave records is the expected three hours, linear interpolation of the graph is carried out to produce a continuous trace. Gaps in the trace indicate missing records due to failure of the recording equipment or to failure of the recorded data to pass the necessary quality control checks.

The data percentage annotated is obtained from the ratio of the number of good records obtained to the number of three hour periods in the month.

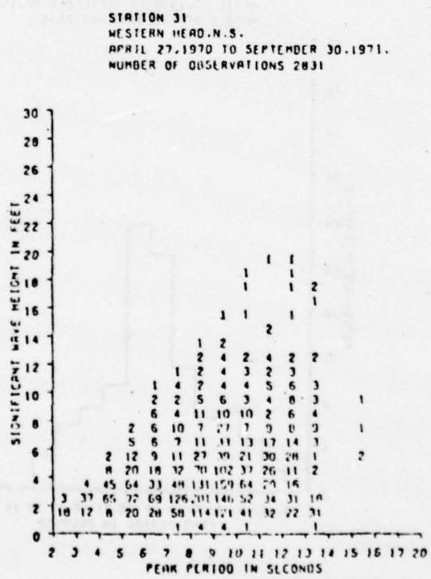


Data Product Description

(4) Scatter Diagram

This diagram shows the number of occurrences of various significant wave heights with various peak periods. The significant wave height for each wave record was computed as four times the square root of the area under the variance spectrum of the water surface elevation. The peak period is defined as the inverse of the frequency at which the maximum spectral density occurred.

The period of time over which the observations were made is annotated at the top of the diagram. The number of observations from which the diagram was prepared is also annotated.

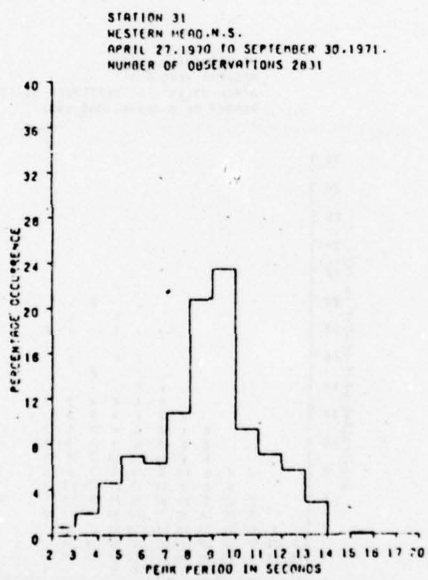


Data Product Description

(5) Peak Period Histogram

This histogram shows the percentage of wave records for which the peak period was in each of the indicated ranges. The peak period for each 20 minute record is defined as the inverse of the frequency at which the maximum spectral density occurred.

The period of time over which the observations were made is annotated at the top of the diagram. The number of observations from which the histogram was prepared is also annotated.

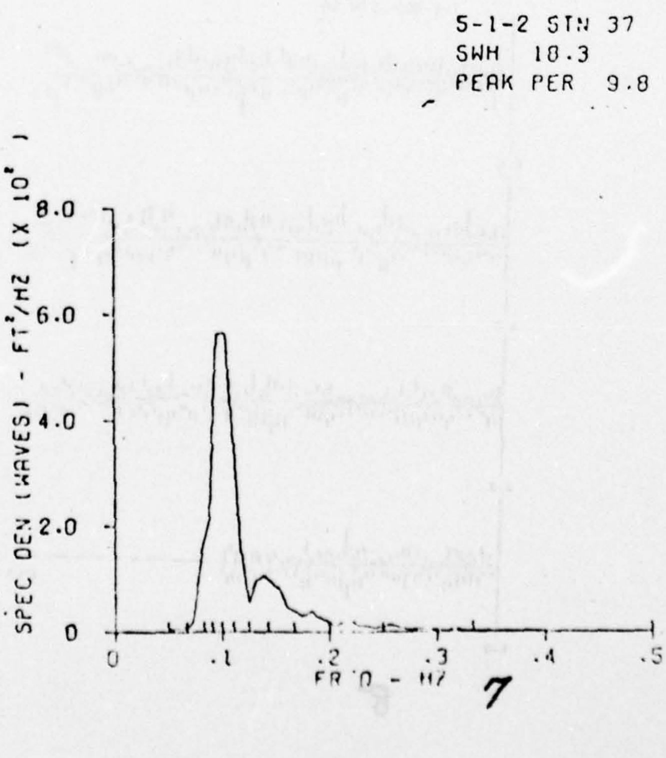


(6) Spectrum Diagram

The spectrum diagram shows the variance spectral density of the water surface elevation as a function of frequency. The densities are computed at approximately 60 discrete values of frequency between 0.05 and 0.5 Hz using the Cooley-Tukey fast fourier transform algorithm. Each twenty minute wave record is broken up into several blocks of 1024 data points. The number of such blocks will be determined by the digital sampling frequency. The final value at each frequency is the average of the densities at the frequency over all the blocks.

If corrections were required for either instrument response or, in the case of a pressure cell, for the attenuation of the pressure fluctuations with depth they will have been applied to the spectrum.

The units of variance spectral density are feet squared per hertz and the units of frequency are hertz. The wave record can be identified by the record-side-tape number and the station number annotated in the upper right hand corner. The time of recording and other pertinent information must come from accompanying documentation. The abbreviations SWH and PEAK PER if they appear are followed by the significant wave height in feet and the peak period in seconds. The peak period is the inverse of the frequency at which the maximum spectral density occurred. The significant or characteristic wave height is four times the square root of the area under the spectrum.



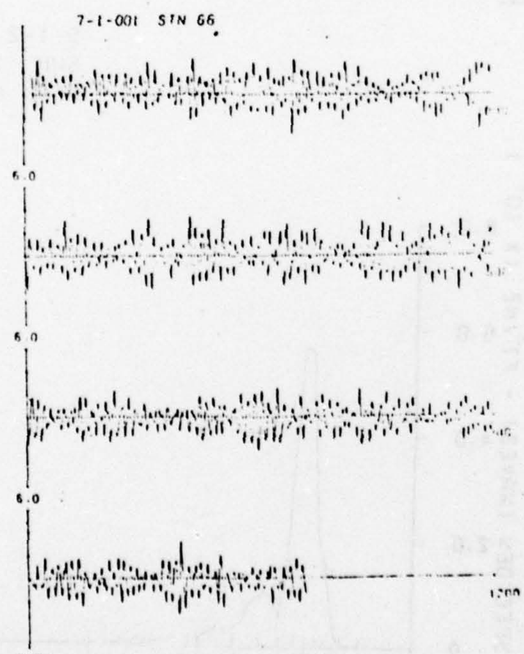
Data Product Description

(7) Surface Elevation Trace

This product is available only for wave records produced by an instrument which does not require substantial frequency dependent response corrections to the recorded sensor signal. For a pressure cell the trace produced will be the pressure as a function of time.

For convenience the twenty minute wave record has been broken up into four 300 second sections. The annotation under the end of the abssisa axis identifies the sections as ending at 300, 600, 900 and 1200 seconds. The annotations appearing between the vertical axes are the plus and minus values in feet (or psi for a pressure cell) corresponding to the maximum and minimum values of the ordinate axes. The position of the assisa axis represents the mean of the record and is defined as the zero of the surface elevation or pressure trace.

The wave record is identical by the record-side-tape number and the station number annotated in the upper left hand corner of the diagram. The time of recording and other pertinent information must come from accompanying documentation.



TIME SERIES REPRESENTATION OF WAVE HEIGHT SPECTRA

The contours depict spectral density (m^2/Hz) as a function of both time and frequency. Heavy dashed lines indicate axes of maximum spectral density. Local winds measured by the buoy are plotted for each observation.

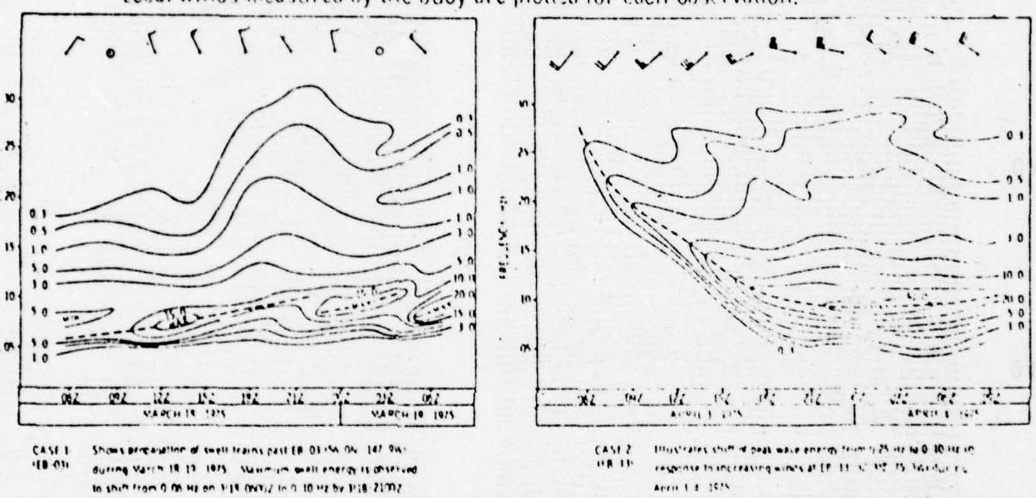


Figure 1. Spectral Wave Time History - NDBO
(NOAA Data Buoy Newsletter, May 1975)

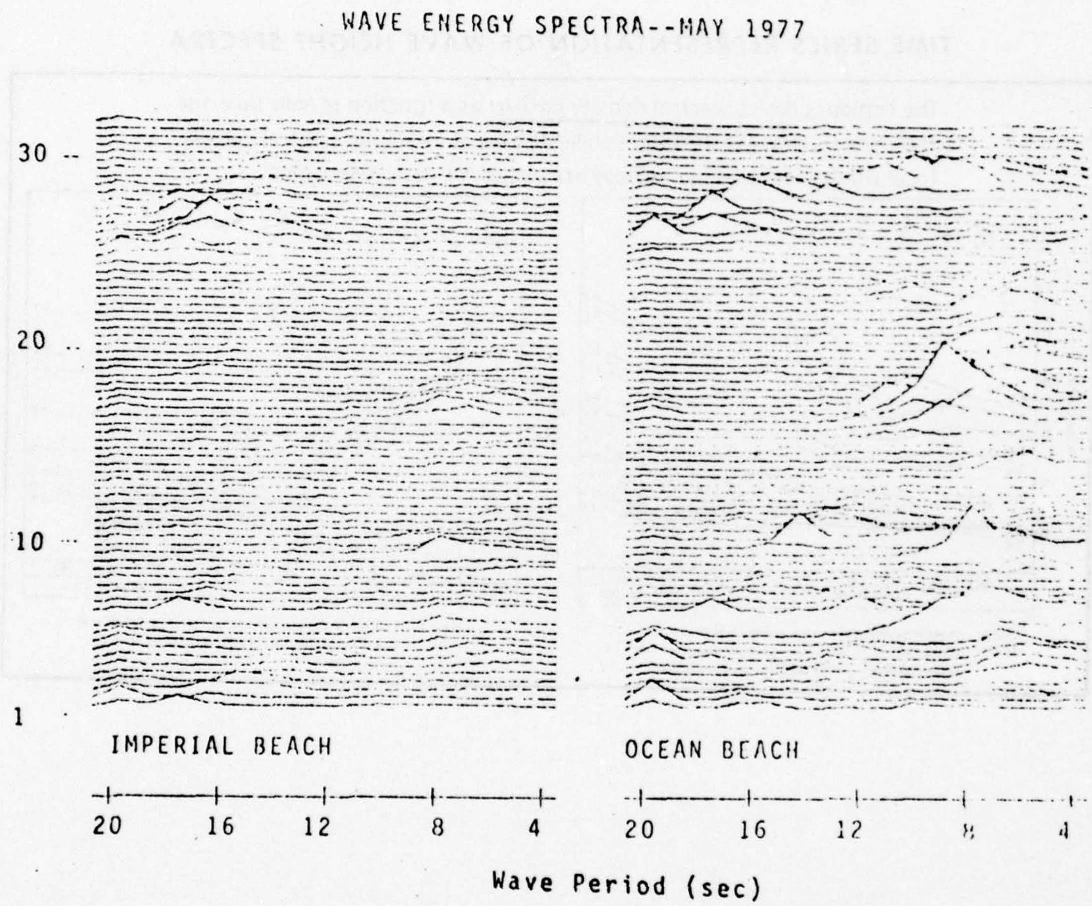


Figure 2. Spectral Wave Time History - DNOD (From California Coastal Engineering Data Network, Monthly Summary Report No. 18, California Department of Navigation and Ocean Development)

Figure 3. Significant Wave Height Versus Average Period

Location: Site A
Base Period: Jan. 1964 to Dec. 1971
Source: Wave Staff Measurements

Winter Season (Dec.-Feb.)

NO OF OBS = 23375

AVG. PERIOD (SEC)	SIG. HEIGHT (FT) 0.0 TO 1.0	1.0 TO 2.0	2.0 TO 4.0	4.0 TO 6.0	6.0 TO 8.0	8.0 TO 10.0	10.0 TO 12.0	12.0 TO 15.0	15.0 TO 18.0	18.0 TO 22.0	22.0 TO 30.0	30.0 AND OVER	LINE TOTAL	MEAN VALUE
0.0- 1.0	1.62	0.31	2.09	0.80	0.14	0.01	0.02	*****	*****	*****	*****	*****	4.97	2.56
1.0- 2.0	2.77	*****	0.15	0.05	0.00	*****	*****	*****	*****	*****	*****	*****	2.97	0.71
2.0- 4.0	3.74	7.91	35.63	10.31	1.39	0.12	0.05	0.03	*****	*****	*****	*****	59.38	3.27
4.0- 6.0	*****	*****	8.21	14.34	4.86	1.16	0.42	0.06	*****	*****	*****	*****	29.05	5.03
6.0- 8.0	*****	*****	0.96	1.45	1.07	0.93	0.63	0.25	0.02	*****	*****	*****	5.30	6.39
8.0-10.0	*****	*****	0.21	0.39	0.25	0.09	0.10	0.02	0.05	0.01	*****	*****	1.12	4.79
10.0-12.0	*****	*****	0.05	0.06	0.03	0.01	*****	*****	*****	0.02	*****	*****	0.16	6.63
12.0-14.0	*****	*****	0.01	*****	0.00	*****	*****	*****	*****	*****	*****	*****	0.02	4.00
14.0-16.0	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	0.0	0.0
16.0-18.0	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	0.0	0.0
18.0-20.0	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	0.0	0.0
20.0-22.0	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	0.0	0.0
COLUMN TOTALS	5.15	8.21	47.51	27.38	7.75	2.31	1.22	0.36	0.07	0.03	0.0	0.0	100.00	3.87
CUMUL. TOTALS	100.00	94.85	86.64	39.13	11.74	3.99	1.63	0.46	0.10	0.03	0.0	0.0		

Significant wave height calculated as average of one-third highest waves

Average Period is Calculated as Zero-Upcrossing Period

3

Figure 4. Wave Persistence

Location: Site A
Base Period: Jan. 1964 to Dec. 1971
Source: Wave Staff Measurements

Significant wave height calculated as average of one-third highest waves

STORM PERSISTENCE LEVEL ------> (SIGNIFICANT WAVE HEIGHT (FEET))	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00
NUMBER OF OCCUR.	2679.	1113.	368.	144.	51.	19.	7.	2.	0.	0.
AVERAGE (HOURS)	10.24	7.40	7.61	8.19	6.29	6.00	6.00	10.50	0.0	0.0
MAXIMUM (HOURS)	108.00	78.00	72.00	66.00	18.00	12.00	12.00	12.00	0.0	0.0
MINIMUM (HOURS)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	9.00	0.0	0.0
STD DEV (HOURS)	11.62	7.56	7.84	8.44	4.36	3.23	3.93	1.50	0.0	0.0
AVG NO PER YEAR	335.	139.	46.	18.	6.4	2.4	0.88	0.25	0.00	0.00
PRCTNGE. OF OCCUR.	39.15	11.76	4.02	1.70	0.46	0.17	0.07	0.02	0.0	0.0
% OVER 3. HRS	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.0	0.0
% OVER 6. HRS	63.05	52.83	52.99	59.03	47.06	52.63	42.86	100.00	0.0	0.0
% OVER 12. HRS	29.19	19.23	19.29	23.61	19.61	10.53	28.57	50.00	0.0	0.0
% OVER 24. HRS	10.04	4.40	5.43	4.86	0.0	0.0	0.0	0.0	0.0	0.0
% OVER 36. HRS	4.70	1.35	1.90	2.08	0.0	0.0	0.0	0.0	0.0	0.0
% OVER 48. HRS	2.20	0.72	0.54	0.69	0.0	0.0	0.0	0.0	0.0	0.0
% OVER 60. HRS	1.27	0.36	0.27	0.69	0.0	0.0	0.0	0.0	0.0	0.0
% OVER 72. HRS	0.52	0.18	0.27	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% OVER 120. HRS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% OVER 180. HRS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% OVER 240. HRS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% OVER 360. HRS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

CALM PERSISTENCE LEVEL ------> (SIGNIFICANT WAVE HEIGHT (FEET))	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00
NUMBER OF OCCUR.	2678.	1112.	367.	143.	50.	18.	6.	1.	0.	0.
AVERAGE (DAYS)	0.66	2.31	7.58	19.72	56.20	144.07	371.02	2206.50	0.0	0.0
MAXIMUM (DAYS)	10.13	46.88	146.75	232.00	319.62	1046.12	2180.87	2206.50	0.0	0.0
MINIMUM (DAYS)	0.13	0.13	0.13	0.13	0.13	0.13	3.38	2206.50	0.0	0.0
STD DEV (DAYS)	0.83	3.87	14.99	39.12	83.96	260.20	0.0	0.0	0.0	0.0
PRCTNGE. OF OCCUR.	60.85	88.24	95.98	98.30	99.54	99.83	99.93	99.98	0.0	0.0
% OVER 1.00 DAYS	17.81	45.59	64.58	74.13	82.00	83.33	100.00	100.00	0.0	0.0
% OVER 2.00 DAYS	6.27	31.21	52.32	63.64	82.00	83.33	100.00	100.00	0.0	0.0
% OVER 3.00 DAYS	2.65	22.03	44.41	54.55	74.00	72.22	100.00	100.00	0.0	0.0
% OVER 5.00 DAYS	0.60	12.86	32.97	47.55	70.00	66.67	66.67	100.00	0.0	0.0
% OVER 7.00 DAYS	0.11	7.91	27.25	41.96	60.00	61.11	50.00	100.00	0.0	0.0
% OVER 10.00 DAYS	0.04	5.04	22.34	35.66	54.00	55.56	50.00	100.00	0.0	0.0
% OVER 14.00 DAYS	0.0	2.25	15.26	30.07	50.00	55.56	33.33	100.00	0.0	0.0
% OVER 30.00 DAYS	0.0	0.18	4.36	18.88	42.00	38.89	16.67	100.00	0.0	0.0
% OVER 60.00 DAYS	0.0	0.0	1.63	7.69	24.00	27.78	16.67	100.00	0.0	0.0
% OVER [illegible] DAYS	0.0	0.0	0.82	5.59	[illegible]	27.78	16.67	100.00	[illegible]	0.0

Figure 5. Monthly Averages of Significant Wave Height

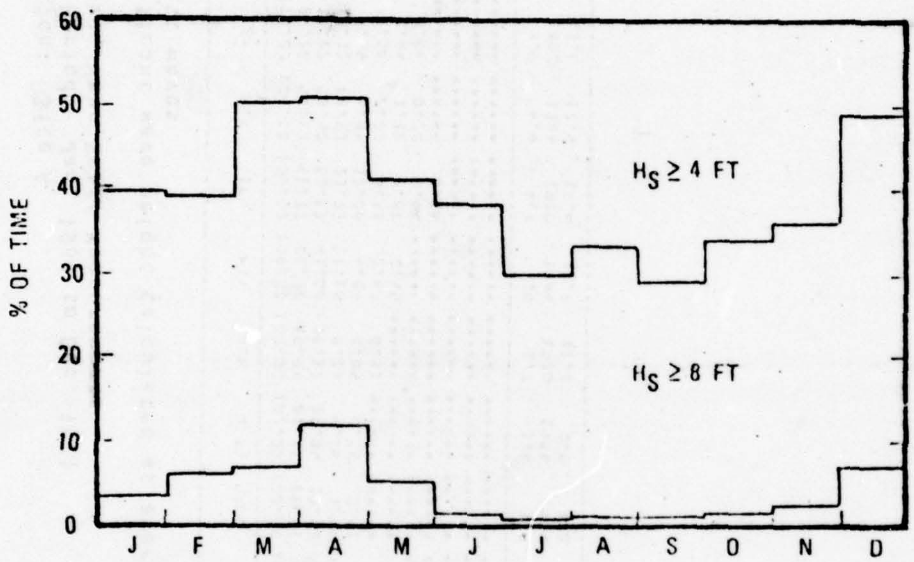
Location: Site A
Base Period: Jan. 1964 to Dec. 1971
Source: Wave Staff Measurements

Significant wave height calculated as average of one-third highest waves

PERCENT GREATER THAN OR EQUAL TO: CONTAINED SIG. HEIGHT (FT)	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT	NOV	DEC	YEAR
0.0	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2.0	90.95	84.22	90.93	91.77	88.86	89.74	87.15	89.71	95.78	82.16	86.35	93.13	86.64
4.0	33.96	38.22	50.50	53.83	41.08	38.12	29.95	23.82	29.06	34.07	35.89	48.65	39.13
6.0	10.33	16.33	18.90	23.23	11.19	8.23	4.18	5.54	6.09	10.94	9.64	16.72	11.74
8.0	3.48	5.95	6.95	12.06	4.94	1.05	0.50	0.51	0.99	1.56	2.81	7.08	3.99
10.0	1.36	1.56	2.72	5.73	2.67	0.31	******	******	0.36	0.40	1.41	3.16	1.68
12.0	0.19	0.44	1.16	2.60	0.35	******	******	******	0.26	0.15	0.10	0.30	0.46
15.0	******	0.06	0.20	0.94	******	******	******	******	******	******	******	******	0.10
18.0	******	******	******	0.36	******	******	******	******	******	******	******	******	0.03
22.0	******	******	******	******	******	******	******	******	******	******	******	******	0.0
30.0	******	******	******	******	******	******	******	******	******	******	******	******	0.0
40.0	******	******	******	******	******	******	******	******	******	******	******	******	0.0
MEAN HEIGHT (FT)	3.7	3.9	4.4	4.7	3.9	3.7	3.4	3.5	3.4	3.9	3.7	4.2	3.8
NO OF OBS	1934	1800	1984	1920	1584	1920	1984	1984	1920	1954	1920	1992	22376
MAXIMUM	12.5	15.8	17.9	19.4	12.9	11.8	9.5	9.2	12.6	13.7	13.4	14.1	19.4

5

Location: Site A
Base Period: Jan. 1964 to Dec. 1971
Source: Wave Staff Measurements



H_s = Average of Highest One-Third Waves

Figure 6. Monthly Averages of Significant Wave Height

CUNY INSTITUTE OF MARINE AND ATMOSPHERIC SCIENCES
AT THE CITY COLLEGE
Convent Avenue at 138th St
New York, N.Y. 10031

6 June 1977

Mr. Wellington Waters
Oceanographer
Data Systems Formulation and
Integration Branch
United States Dept. of Commerce
National Oceanic and Atmospheric Admin.
Environmental Data Service
NATIONAL OCEANOGRAPHIC DATA CENTER
Washington, DC 20235

Dear Mr. Waters,

In reply to your request dated May 23, 1977, I am pleased to provide you with my requirements for ocean wave climatological data. In response to your summary of the presently available data, beginning at the bottom of the first page of your letter, I find that most climatological breakdowns are not very useful. These data products are useful in a limited number of applications, but it has been my experience that one is usually interested in a sequence of storms and that such sequences are reshuffled so badly by the time they are summarized in such tables it is impossible to recover a coherent picture of what actually happened. The data that you describe are probably satisfactory for much of the lower level less intense purposes of primitive design considerations for offshore structures, and what have you.

You mention only briefly the availability of wave spectra. It is my opinion that wave spectra arranged in chronological order for each site that is capable of obtaining ocean wave time histories would be the most important kind of data that could be made available. A concerted effort to obtain the appropriate transfer function to calibrate the spectrum properly is essential. For example, we are not completely convinced as of this date that the spectra published by the National Data Buoy Office have been correctly obtained from the original accelerometer data. Some efforts are being made by other scientists to compare the spectra with what our spectral ocean wave model predicts for the same area

at the Fleet Numerical Weather Central. The descrepancies are rather strange, and if they are due to the model (under the assumption that the spectra provided from the data buoy are correct) then some interesting problems arise. However, the meager amount of literature on the design and calibration of the wave sensing system on the data buoys has failed to convince me that everything is correct in this area. Apart from this however, there are a large number of ocean wave records available and that recently have been archived. The data being provided by the oil companies is one example. It eventually does get released to the public domain. In my opinion, spectra should be calculated from all such available data and properly archived.

An example of one way to handle this problem is given in the text book by Dr. Neumann and me, "Principles of Physical Oceanography" published by Prentice-Hall in 1966. I refer you to pages 348 and 349. The data in this particular case consisted of the raw spectral estimates from the Tucker ship-borne wave recorder. A correction for digitation error is made, a further correction for the transfer function of the wave recording system is shown, and finally some basic statistics calculated from the final spectra are given. The wave characteristics calculated from the spectrum were the average period, which is based on the square root of the ratio of the second moment to the zero moment, the significant wave height, and the total degrees of freedom of the entire sample, which can be calculated from the spectrum and knowledge of the degrees of freedom for each spectral band. This calculation is different if a fast Fourier transform is used. From the total degrees of freedom, it is possible to calculate a 90% fiducial confidence interval on the significant height. This is an extremely important number because those who are uneducated in the field of sampling variability tend to believe that significant height is a number good to several significant figures, whereas typically the wave height even after being measured by a wave recording system is known to only plus or minus ten or fifteen percent, given a twenty minute long ocean wave record. Those who use these data should be forced to use more intelligent statistical concepts in interpreting the data than have been used up to the present time.

The enclosed reprint shows the kinds of quantities that we can calculate from theoretical ocean wave spectra. These values are shown in Figure 7. Similar quantities can be computed from a spectral estimate

given an ocean wave time history. It is of course not possible with a wave recorder that simply senses the rise and fall of the sea surface at a point to say anything about which way the waves are going. The average wave period in this table is calculated in the way that it was calculated in the text. The significant wave period is simply the first moment of the spectrum devided into the zero moment with the appropriate number of 2π's to yield the correct dimensions. The significant wave period calculated in this way comes from certain probability density functions discussed many years ago in a book by me, and recently expanded upon in publications by Bretschnider and Longuit-Higgins. This period is usually longer than the average period, and it represents quite well the time intervals between the crest of the one-third highest waves in the time history.

Once a wave spectrum is produced, many other interesting calculations can be made such as the expected value of the highest wave in the record. This could be compared with the actually measured highest wave in the record. Under the assumption that the spectrum was not going to change over a number of hours, the expected value of the highest wave in a thousand, or two thousand, could also be calculated. These would be useful statistical quantities for many design considerations.

One of the problems that seems to be surfacing in the study of ocean waves has to do with the nature of the wave spectrum at the higher frequencies. For periods corresponding to frequencies of 0.25 Hz and higher (waves with periods of 4 seconds or shorter), the responses of the various wave recording systems that have been employed differ substantially. As one example, the Tucker Ship-borne wave recorder given practically no signal at all at these frequencies, and the calibration correction given in Neumann and Pierson supplies the shape of the curve in this area. In attempting to study the behavior of wave spectra as a function of fetch, which is being done today at a number of organizations, changes produced by the effects of instrument calibration seem to be being confused with the real physical features in the waves. It is therefore extremely important to document the frequency range over which the instrument is satisfactory and to document whatever calibration function has been applied to the raw data in order to recover the ocean wave spectra. *

I hope that this information will be helpful to you. If you have any further questions please contact me. Please note the correct spelling of my name.

Yours sincerely,

Willard Pierson

Willard J. Pierson
Professor

WJP:jb

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ANNAPOLIS, MD 21402
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BETHESDA, MD 20084

IN REPLY REFER TO:
1568:SLB
5230

05 AUG 1977

United States Department of Commerce
National Oceanic and Atmospheric Administration
National Oceanographic Data Center
Washington, D.C. 20235

Attention: Mr. Wellington Waters, Sr.

Gentlemen:

The ongoing coastal wave data collection and storage program, sponsored by the National Oceanic and Atmospheric Administration (NOAA) and described in your letter of 29 June 1977, is of interest and could prove to be beneficial to certain David W. Taylor Naval Ship Research and Development Center (DTNSRDC) users. Specific applications may be in the areas of design of amphibious and high performance craft as well as in operational planning of naval surface ships in general. In addition, the data could be of some use in examining the validity of wave spectral models currently used in design work.

As requested in your letter, enclosure (1) is forwarded to identify specific wave data requirements of DTNSRDC users. A background discussion of some of these requirements is contained in enclosure (2).

It should be noted that from many viewpoints, open-ocean, deep-water wave data are of primary importance to the naval ship designer and operator. This is true because most naval ships spend more time at-sea than along the coasts, and because the occurrence of wave phenomena which have a greater deleterious effect on ship performance is generally believed to occur at sea. It is therefore recommended that NOAA consider naval operational areas in selecting buoy locations for future measuring sites. Locations in deeper water as far at sea as possible, and in heavily steamed waters would be highly recommended.

Should you have questions or comments regarding this letter or the enclosures, please feel free to contact Mrs. S. L. Bales, telephone number 202/227-1817.

Incl 3 to 3 Nov Letter

1568:SLB
5230

Further discussion regarding wave data access and methods of display would be welcomed.

Sincerely yours,

W E Cummins

W. E. CUMMINS
Head, Ship Performance Department

Encl:
(1) DTNSRDC Wave Data Requirements
(2) Wave Data Requirements for Ship Design and Ship Operation

Copy to:
NOAA (NOS C33, M. Earle)
NAVSEC 6114B
NAVSEC 6136

DTNSRDC WAVE DATA REQUIREMENTS

1. In general, DTNSRDC wave data users have found that Canada's Marine Environmental Data Service (MEDS) system is highly useful and satisfactory for coastal applications. If NODC adopts such a storage, retrieval, and display system, a few specific features are recommended for inclusion:

a. a complete description of the oceanographic and geological features of each measurement site;

b. correlation of wave parameters with wind parameters across time;

[illegible]

storage of wave parameters (height, period, and direction where possible) in such a manner that ranges, especially in the upper regions are sufficiently defined for application in ship performance evaluations;

d. high period (> 25 seconds) energy tabulated if possible;

e. seasonal variations included by cumulating data by monthly increments;

f. measurement of directional spectra at a few of the measurement sites;

g. easy access to interesting spectral data, e.g. growth and decay of storms, swell degraded wind spectra (multi-peaked spectra), directional spectra, etc.

2. Keys to the success of the NODC system may reside in the ease of access of the data and in the types of data displays adopted. A few recommendations concerning these matters are specified:

a. spectral and other tabulated data be available by hard copy, cards and magnetic tape; hard copy could be further stored on microfiche;

b. available data, by location and time, should be advertised periodically to potential users;

c. data should be made available quickly when requested;

d. data should be accessible by both location and month;

* e. preferred displays by current wave data users, both commercial and government, and both civil and naval engineers, should be surveyed.

El Paso MARINE COMPANY

[illegible] ALL[illegible] [illegible]ARKWA[illegible]
P. O. BOX [illegible]
HOUSTO[illegible] TEXAS [illegible]

PHONE [illegible]521-580[illegible]
TELEX [illegible] 762 6[illegible]5
(EPLNGCOS HOU B)

September 15, 1977

Mr. Wellington Waters
United States Department of Commerce
National Oceanic and Atmospheric Administration
National Oceanographic Data Center
Washington, D.C. 20235

Dear Mr. Waters:

I received a copy of your letter addressed to Mr. Don Crutchfield, dated August 30, 1977, and I am prompted to respond to your wave data format request. I am very pleased to assist in your efforts to establish standard rules, procedures, definitions, and format for a new instrument *measured wave data retrieval system.*

I am involved in marine transportation studies of liquefied natural gas by ships. In this work, wave data is used in three ways; site selection for marine terminals; simulation of marine terminal weather and wave conditions for establishing fleet and marine terminal configurations; and engineering design for marine terminal construction. The essential wave data used in these studies takes the form of significant and maximum waves occurring at the sites.

Canada's Marine Environmental Data Service output that may be of use to me is in the form of (1) exceedance diagrams, (2) wave height versus wave period printouts, and (3) peak period histograms showing various wave period occurrences. As far as our specific wave data requirements are concerned, I have enclosed five wave data format examples. The examples include:

- Average percentage occurrence of significant wave height by direction groups as shown by Table 15 (by selected months and annual summary).

- Average annual percentage occurrence of significant wave period in selected wave height categories as shown by Table 16.

- Average percentage occurrence of exceedances of storms as shown by Table 21 (by selected months and annual summary).

Incl 4 to 3 Nov Letter

- Maximum and significant storm wave heights by recurrence interval as shown by Table 25.

- Average interval in years between occurrences of maximum and significant wave height as shown by Figure 3.

I wish you the best in the development of this new wave data retrieval system. If I can be of further assistance, please contact me.

Sincerely,

Stephen T. Maloy

Stephen T. Maloy
Senior Marine Systems Engineer

STM:bd

Attachments (5)

TABLE 15: AVERAGE PERCENTAGE OCCURRENCE OF SIGNIFICANT WAVE HEIGHT - DIRECTION GROUPS: SPECIFIED 40 TO 45 FOOT CHART DEPTH AFTER DREDGING: ANNUAL

Direction	Significant Wave Height Groups (Feet) 0-0.9	1-1.9	2-2.9	3-3.9	4 PLUS	Total
N	5.1	6.5	0.7	0.0	0.0	12.3
NE	2.7	5.0	2.2	0.4	0.0	10.3
E	3.7	6.6	2.3	0.4	0.1	13.1
SE	14.3	17.5	1.9	0.1	0.0	33.8
S	19.6	0.0	0.0	0.0	0.0	19.6
SW	3.7	0.0	0.0	0.0	0.0	3.7
W	2.0	0.0	0.0	0.0	0.0	2.0
NW	2.8	2.3	0.1	0.0	0.0	5.2
Total	53.9	37.9	7.2	0.9	0.1	100.0

TABLE 16: AVERAGE ANNUAL PERCENTAGE OCCURRENCE OF SIGNIFICANT WAVE PERIOD IN SELECTED SIGNIFICANT WAVE HEIGHT CATEGORIES:

SPECIFIED 40 TO 45 FOOT CHART DEPTHS AFTER DREDGING

Significant Wave Period (Seconds)	Significant Wave Height (Ft.) 0-0.9	1-1.9	2-2.9	3-3.9	4 Plus
0-4	93.1	90.5	87.4	83.5	78.0
5-6	5.9	7.7	9.9	12.8	17.2
7-8	1.0	1.7	2.5	3.3	4.2
9 Plus	0.0	0.1	0.2	0.4	0.6
Total	100.0	100.0	100.0	100.0	100.0

Approximate Wave Lengths For 0 to 4 Foot Significant Wave Heights in 40 and 45 Foot Depths

Significant Wave Period (Seconds)	Wave Length (Feet) 40 Ft Depth	45 Ft Depth
0-4	0 - 83	0 - 83
5-6	125 - 168	127 - 173
7-8	211 - 252	218 - 263
9 Plus	292 Plus	304 Plus

TABLE 21: ANNUAL AVERAGE PERCENTAGE OCCURRENCE OF EXCEEDANCES OF "STORMS" (INTERVALS WHEN SIGNIFICANT WAVE HEIGHT EXCEEDS SPECIFIED HEIGHT FOR DURATIONS GREATER THAN OR EQUAL TO THAT SPECIFIED): SPECIFIED

40 TO 45 FOOT CHART DEPTH AFTER DREDGING

Significant Wave Height (Feet)	Duration (Hours) ≥0	≥6	≥12	≥18	≥24	≥36	≥42	≥48	≥72	≥90	≥120	≥240	≥360	≥348
>1	44.9	44.9	39.7	37.8	36.3	32.9	30.7	28.7	22.0	17.5	9.1	0.0	0.0	0.0
>2	9.1	9.1	6.5	5.3	4.3	2.4	1.5	1.5	0.0	0.0	0.0	0.0	0.0	0.0
>3	1.2	0.9	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE 25: MAXIMUM AND SIGNIFICANT STORM WAVE HEIGHTS:

SPECIFIED 40 TO 45 FOOT MEAN LOW WATER DEPTH AFTER DREDGING

	Recurrence Interval					
	100 Year	50 Year	25 Year	10 Year	2 Year	1 Year
Maximum Wave Height (Feet)	17.3	14.1	11.8	9.9	9.0	8.4
Significant Wave Height (Feet)	9.3	7.6	6.3	5.3	4.8	4.5

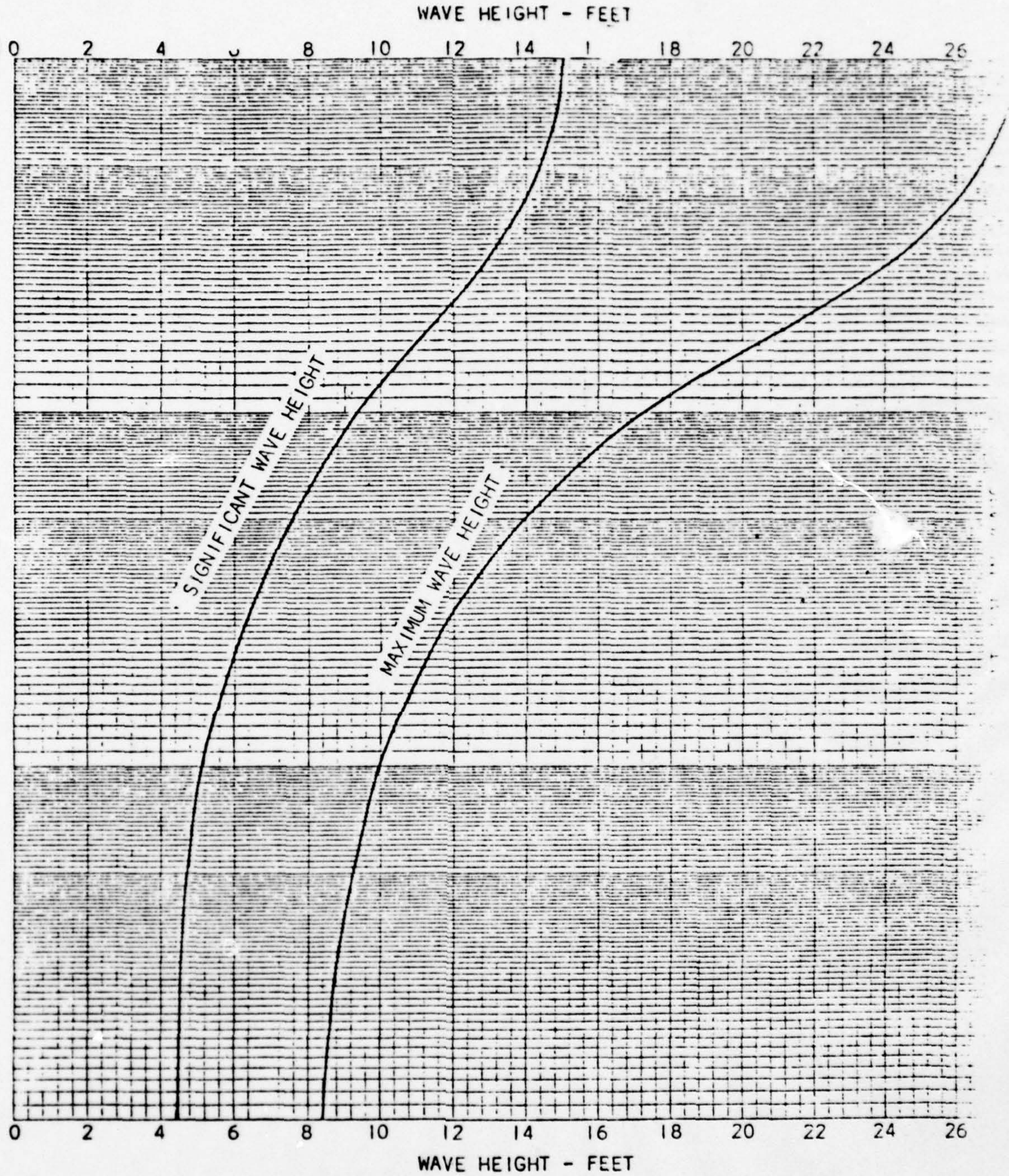


FIGURE 3

AVERAGE INTERVAL IN YEARS BETWEEN OCCURRENCES OF MAXIMUM AND SIGNIFICANT WAVE HEIGHT:

SPECIFIED 40 TO 45 FOOT CHART DEPTH AFTER DREDGING

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
ENVIRONMENTAL DATA SERVICE
NATIONAL OCEANOGRAPHIC DATA CENTER
Washington, DC 20235

Date: April 15, 1977 Reply to: D752/WW

To : FILE

From: Wellington Waters, Sr.
Data Systems Formulation and
Integration Branch

Subj: The Canadian MEDS Wave Data System

1. This memorandum forwards a product titled Some Aspects of Canada's MEDS Wave Data System (see enclosed). This information was compiled from quite a bundle of material received by me from Dr. J. R. Wilson of MEDS about March 31, 1977. Included in the package was some information on MEDS wave instruments, their field data reception and recording devices, their data processing procedures and an up-to-date (as of January 14, 1977) inventory of their processed instrument measured wave data.

2. What the Canadians did not forward at this time, which was requested, were the programs, mathematical formulas and associated documentation which operate their wave data system. However, Dr. Wilson has indicated that they are now in the process of developing improved documentation on their programs and formulas and should be able to put together, for us, a package of these products in about two months.

3. The material forwarded thus far, is not in one well organized publication, but appears to be products generated as various national and international motivations demanded. Some of the information on data processing was written in July 1973. Therefore, some new procedures and practices may have been developed by now. Though the material received provides much desirable information in these initial stages of NODC's wave system developmental effort, they also raise as many or more questions as or than they answer.

Enclosure

cc:
D7
D75
D752
D76
D761

Incl 5 to 3 Nov Letter

SOME ASPECTS OF CANADA'S MEDS
WAVE DATA SYSTEM

I INSTRUMENTS

The Canadians catagorize wave instruments, basically into three groups. These, for their purposes, are: first, second and third generation instruments which use the techniques of (1) visual observations made against staffs and float operated gauges; (2) more sophisticated pressure and accelerometer sensors; and (3) even more sophisticated radar, lasar and magnetometer sensors, respectively. Some instruments overlap in this categorization. Their categories also signify, to a great extent, the historical use and development of wave instruments.

As far as is known by me at this time, the Canadians use modern wave staffs, step gauges, pressure sensitive and accelerometer instruments in their wave measuring program. The one instrument they use which they identify, is the Datawell Waverider, a second generation instrument developed by the Dutch. In fact, most information received thus far, indicates that waveriders and pressure sensors are perhaps their most frequently used instruments. Wave staffs and step gauges are probably less used because they require rather large and complex stable platforms for use, especially in unsheltered areas. The Atlantic Oceanographic Laboratory (A.O.L.) of Canada has, however, developed a small stable platform suitable for sheltered water areas.

Pressure gauges, most conveniently mounted on the sea bottom, are usually linked with a shore based recorder by some form of cable. Their primary advantage is their freedom from hazard. A couple of their primary short comings are that the gauge-recorder cable link is length restrictive, thus restricting its use to near shore areas; and, since it is ~~more~~ wave length-height sensitive, the high frequency waves often are undetected.

On the other hand, the accelerometer buoys (waverider, etc.) can be deployed up to 30 miles off shore since the buoy-recorder link is telemetry. However, they are hazard prone, tend to miss long period-low height waves, and since the remote sensing is powered by batteries, the operating life span of the batteries causes some limitations.

Signals from the Datawell Waveriders used by the Canadians, are recorded using the WAREP recorder system which is a receiving-recording assemblage. I believe the analog tape and strip chart recorders tied in with the receiver are Canadian modifications. The WAREP is supplied by the Dutch Datawell manufacturers as a component of the Waverider package. The Canadians feel that the receiving-recording system they have set up is quite reliable. However, daily checks are made to assure proper functioning of the complete sensing-recording system.

Basically, the waverider system functions as follows:

(a) The waverider telemeters wave height-wave period signals continuously.

(b) At three hour intervals, the receiving and recording assemblage is automatically turned on.

(c) The analog tape recorder records for a period of twenty minutes, though it operates for a while longer than twenty minutes.

(d) The strip chart recorder can also record the twenty minute message; however, it is used intermittently, primarily as a quality control device unless the tape recorder malfunctions. In this case, the strip chart recorder can record the wave data. The analog tape used, record for a period of 8 days, after which the tapes are mailed to MEDS for processing.

MEDS has establised a rather extensive list of specific tape moni-*toring procedures* for received tapes. Some are: (1) checks for general conditions of tape reels and wound tape, (2) proper labelling of tapes (dates, time, station identity, etc.), (3) visual and scope scrutiny of wave records, (4) checks for completeness of wave records per time period of operation, (5) signs of station equipment problems, and so forth. They have also established predigitizing checks for wave record tapes and some diagnosis for certain tape features.

II <u>DATA PROCESSING</u>

A. The digitization System

The Canadian digitization system is specially designed for converting the on site recorded analog tape data to computer compatible digital magnetic tapes. The components of the system are: (1) a small

general purpose computer, (2) two digital incremental magnetic tape units, and (3) some constant frequency counters. Some counters measure the time between pulses of the on site recorded frequency modulated signal. The inverse of these times are frequencies which are linerally proportional to the wave sensor signals. At the same time, another counter is monitoring another channel of the tape on which is recorded a constant frequency signal. (The on site analog tape has, I believe, 4 channels. The wave signal and oscillator signal go on channels 2 and 3, and 1 and 4, respectively.) So, apparently the first frequency counters are monitoring the wave signal while the latter is monitoring the oscillator signals. I believe the oscillator signal is a reference signal. The monitoring of these two signal types enable the computer to correct for the tape recorders' small fluctuations. Without the corrections, the tape recorder "noise" (fluctuations) could appear as waves of low heights with periods in the 2-20 second range - the range of most wind generated waves. Long period waves of 1/2 foot or so could be important. Also generator power line frequencies fluctuate (as much as 5-10 percent) and corrections are made for these fluctuations. The combined corrections for tape recorder and generator noise are reduced to less than one half inch of the wave height in the Canadian data processing. *The data stored on digital magnetic tapes are the <u>corrected times between pulses</u> measured by the computer (digitization system). These files are stored for further processing and future unanticipated data applications. One year of this data for one station requires four 2400 foot reels of magnetic tape recorded at 1600 bpi. This can require

significant storage space; however, the Canadians feel that the present practices can be altered to reduce by one half or more, the storage requirements.

B. Data Processing (Analysis)

The Canadians use the term "Processing" as applied to wave data, to mean "analysis" as loosely applied by some of us in producing analytic output products such as histograms, roses, cumulative frequency diagrams and the like. So, in their processing documentation, they are referring to the output products (exceedance diagrams, peak period histograms, scatter diagrams, etc.) derived by manipulating the data stored on a second set of tapes, the contents of which is given below.

Their processing requires the computation of the spectrum of each 20 minute record. This implies up to 2,900 spectra per station per year. Spectra are generated using the mathematical operation - the fast Fourier Transform Algorithm. It was found that most of the pressure cell and accelerometer buoy instruments data required this type of processing; both instrument types required a frequency dependent amplitude correction. Most data records had high and low frequency noise superimposed on the wave signal. Most of this noise, however, is outside the range of wind generated wave frequencies and automatically are eliminated since the computations are restricted to the wind wave frequencies.

The two main parameters routinely derived are the <u>characteristic wave height</u> and the <u>peak period</u>. The characteristic wave height is defined as four times the square root of the zeroth moment of the spectrum ($4\sqrt{Mo}$). The peak period is the period corresponding to the frequency

at which the maximum spectral density is observed. These two parameters for each 20 minute records are stored on their second file tapes. Also stored on these second file tapes for each 20 minute record, are about 60 estimates of spectral density evenly incremented between the frequencies 0.05 Hz (20 sec. per cycle) and 0.5 Hz (2.0 sec. per cycle); or waves having periods of from 2 to 20 seconds.

These second files of magnetic tapes are used to generate their statistical summaries, namely the (1) cumulative percentage exceedance diagrams, (2) peak period histograms, (3) scatter diagrams. The first (see figure 1) shows the cumulative percentage of the time the characteristic (significant) wave height exceeds various height values along the abscissa; the ordinate is the percentage axis. The other curve in the figure shows the most probable maximum wave height in a 3 hour period and is derived using Longuet-Higgins theory. Figure 2 is a histogram of the various peak periods. Shown in Figure 3 are the number of occurrances of the peak period - characteristic wave height combinations. Each of these summaries are derived for the complete observation period of collections for one year or longer. These products can also be derived for other specific periods (shorter).

Computer listings showing "equivalent wave heights" for various specified frequency ranges for each twenty minute wave record are also rountine outputs (see Figure 4). The equivalent wave height is obtained by integrating under the spectrum between the frequency ranges shown; and is equal to $2\sqrt{2}$ times the square root of the area under that portion of the spectrum.

Other products made available by MEDS are shown in figures 5, 6 and 7; spectral density verses frequency, water surface elevation versus time, and observed characteristic wave height plotted against time by month, respectively. Figures 5 and 6 are for specified twenty minute records.

III. QUALITY CONTROL

As far as is known at this time, the Canadians check the waverider instrument (their most widely used instrument) and apparently erroneous wave records for quality control. They have a waverider calibration device that was used with 18 buoys and claim the maximum error determined was in amplitude of under 3.8%. Fourteen of the buoys showed an error within 2% of the original calibration; some had operated for as much as 3 years.

Their most difficult error experience is associated with the waverider communications. Most bad records, however, are detectable when the spectrum or water surface elevation trace of records are displayed on an oscilloscope. One person can evaluate the quality of a year's data (2,900 spectra) for one station in a little over a half day. (There remains quite a few questions on their quality control for which information is not yet available. For example, what happens to erroneous records? What is looked for when examining erroneous records? How are they recognized in the first place? Quality control of the pressure gauges? etc.)

IV ARCHIVAL and DATA DISSIMINATION

The wave data archived by the Canadians is held in individual files for each location at which data were collected. As data are digitized, they are appended to their respective files in strict chronological order. For retrieval, and using various programs, required data are recognized by either the extent of field recorded parameters, specified records, tape number and side of tape, or a range of time. A simple search down the tape then proceeds to retrieve the desired data. This is true for both the digitized (corrected time between pulses) data files and, what I call their second file of processed data, the files of characteristic wave heights, peak periods and spectral densities.

The Canadians indicate that 80-90 percent of all requests have been for summaries of all available data for one location; or data for several locations treated singly. The remainder of the requests have been varied and include (1) graphs of surface elevation as a function of time for a number of 20 minute records, (2) computer analysis of wave by wave to detect crests, troughs and zero crossing for the ~~wave~~ more classical analysis, and (3) statistical distributions of wave steepness. (There have been other types of requests, no doubt). They indicate these last types of requests can only be satisfied for a limited amount of data, since the procedures for their derivation are prohibitively expensive. However, spectral density graphs are relatively inexpensive and can be

supplied on magnetic tape if necessary. Also, values of water surface elevation can also be put on magnetic tape. I believe the wave by wave analyses and the water surface elevations are very expensive outputs, since they require band pass digital filtering of the recorded signals.

V. <u>DATA EXCHANGE</u>

Exchange of large volumes of spectral information (and, I suppose, the characteristic wave height-peak period data) are relatively feasible. MEDS indicates that three years of these data (at three hour intervals) can be stored on one 2400 foot tape. They indicate, very strongly however, that the processing (analysis) techniques used for reducing the data would have to be carefully documented. For example, the various methods used to obtain wave period (zero crossing period and peak period) yield vastly different results. Exchange of large volumes of data output products requiring band pass digital filtering, however, are cost prohibitive for the Canadians.

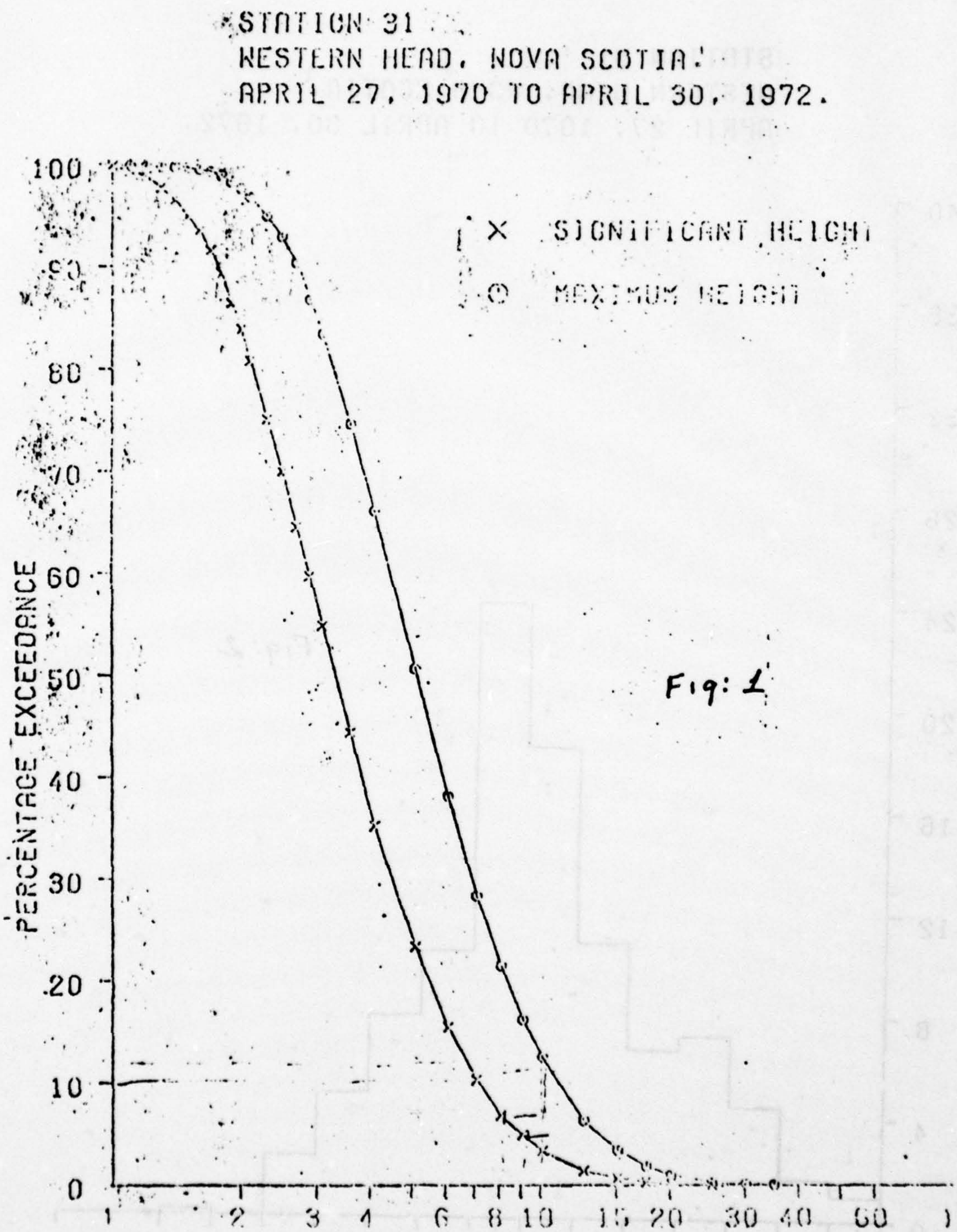

STATION 31
WESTERN HEAD, NOVA SCOTIA.
APRIL 27, 1970 TO APRIL 30, 1972.
× SIGNIFICANT HEIGHT
⊙ MAXIMUM HEIGHT
PERCENTAGE EXCEEDANCE
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
6
8
10
15
20
30
40
60

Fig: 1

STATION 31
WESTERN HEAD, NOVA SCOTIA
APRIL 27, 1970 TO APRIL 30, 1972.

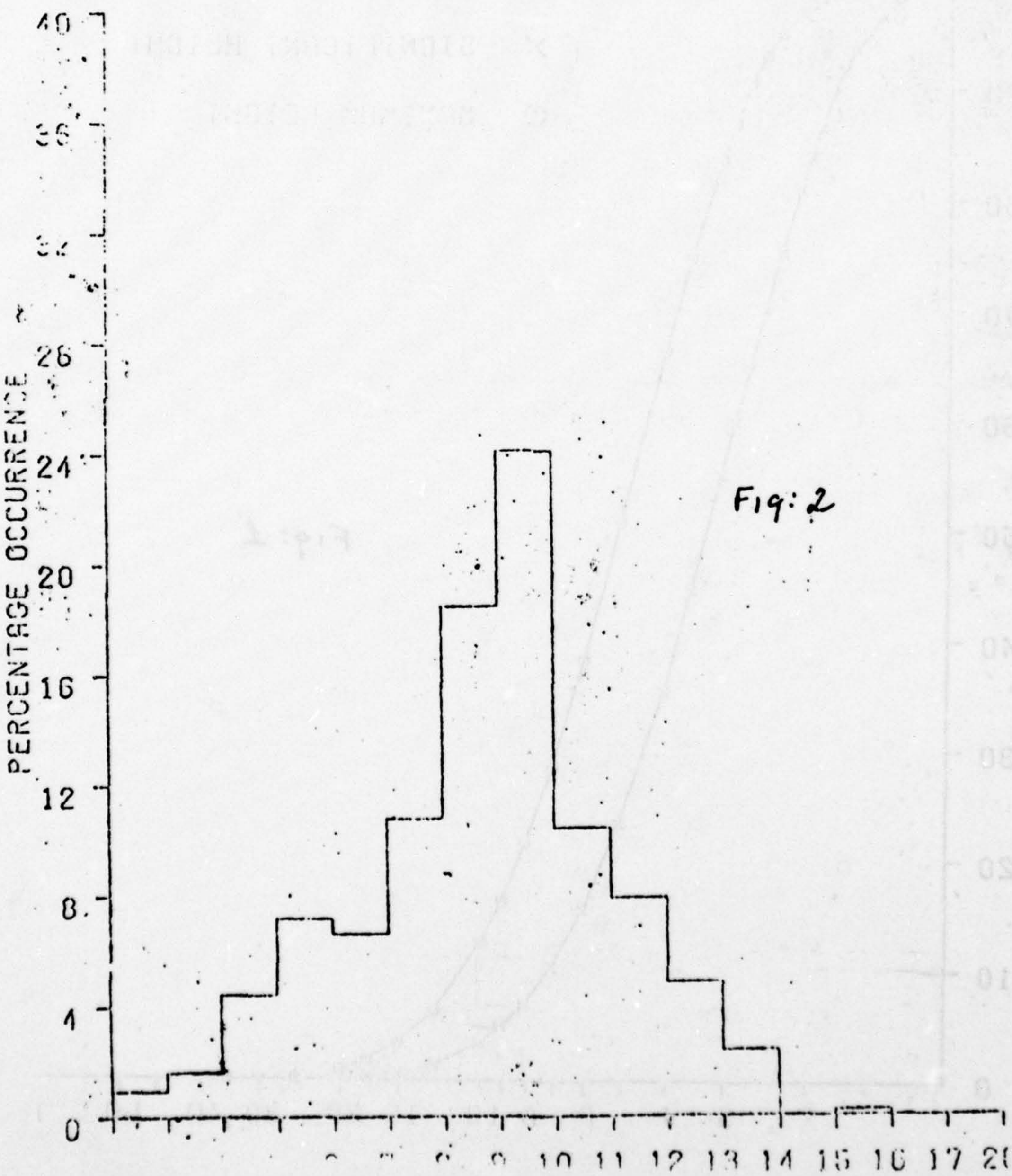
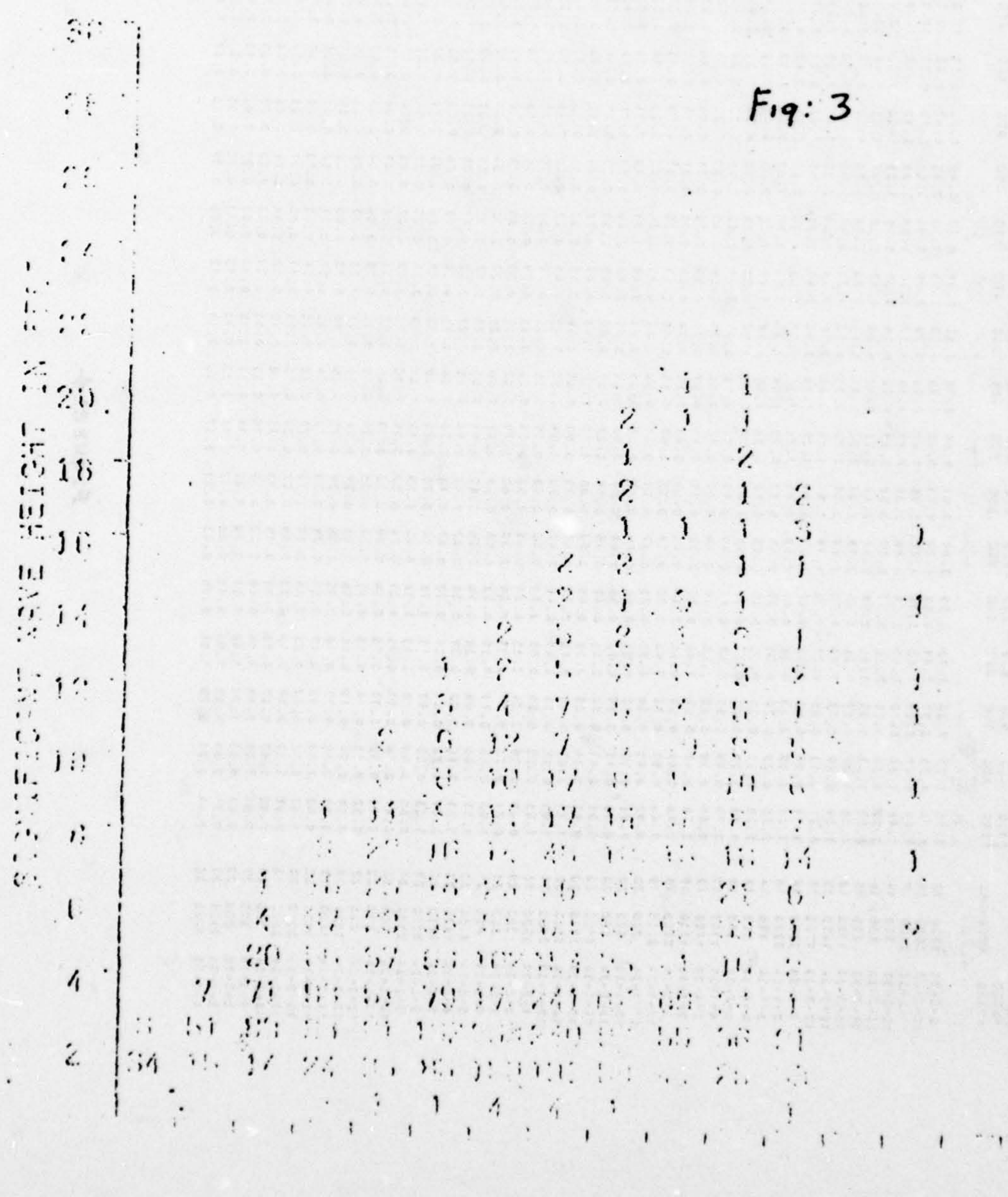


Fig: 2

STATION 31
WESTERN HEAD, NOVA SCOTIA.
APRIL 27, 1970 TO APRIL 30, 1972.

Fig: 3



EQUIVALENT WAVE HEIGHT TABULATED BY WAVE PERIOD

RECORD -SIDE -TAPE	DEC 1970 HOUR	-DAY	2.0 TO 3.0 SEC	3.0 TO 4.0 SEC	4.0 TO 5.0 SEC	5.0 TO 6.0 SEC	6.0 TO 7.0 SEC	7.0 TO 8.0 SEC	8.0 TO 9.0 SEC	9.0 TO 10.0 SEC	10.0 TO 11.0 SEC	11.0 TO 12.0 SEC	12.0 TO 13.0 SEC	13.0 TO 14.0 SEC	14.0 TO 15.0 SEC	15.0 TO 16.0 SEC	16.0 TO 20.0 SEC	2.0 TO 20.0 SEC	WAVE [illegible] FEET SQR.	PEAK PER. SEC.	WIND VEL. KTS.	WIND DIR.
9-2-33	1700	17	1.30	1.77	2.20	2.73	3.59	3.98	5.67	5.08	3.15	1.52	0.37	0.67	0.49	0.30	0.32	12.8	18.7	5.75	36	E
10-2-33	2000	17	1.12	1.73	2.57	2.64	2.80	4.20	4.71	5.62	5.61	5.10	2.55	1.11	0.65	0.67	0.63	13.7	23.5	11.6	38	E
11-2-33	2300	17	1.09	1.47	2.09	2.62	2.36	4.25	3.96	4.47	5.25	9.29	8.08	5.03	3.01	2.79	1.73	17.8	39.3	11.4	42	E
12-2-33	200	18	1.03	1.36	2.19	2.43	2.26	2.86	3.20	2.93	4.15	5.76	7.32	4.83	2.36	2.17	1.40	14.0	28.3	12.4	23	SE
13-2-33	500	18	0.98	1.50	1.28	2.36	2.37	2.37	2.58	3.39	4.48	5.29	5.60	5.15	3.23	1.26	1.33	12.6	19.2	13.7	12	E
14-2-33	800	18	0.92	1.23	1.33	1.95	2.56	2.57	2.48	2.75	4.40	4.65	4.37	5.28	3.47	1.55	1.46	12.1	18.2	13.7	12	E
15-2-33	1100	18	1.18	1.07	1.27	1.35	1.83	2.18	2.07	2.92	4.57	5.54	3.26	4.58	3.25	1.00	1.40	11.0	17.4	11.4	7	E
16-2-33	1400	18	1.24	0.99	1.02	1.40	1.72	1.88	2.01	2.78	2.23	5.02	4.31	2.47	1.52	0.53	0.72	9.09	10.3	11.4	17	NW
17-2-33	1700	18	1.21	1.13	0.65	0.77	1.10	1.14	1.51	1.98	2.30	3.15	3.35	3.31	2.28	1.07	1.25	7.65	7.33	13.7	23	NW
1-1-34	2000	18	1.13	0.37	0.51	0.56	0.67	0.86	0.81	1.28	1.38	2.92	2.60	2.07	1.33	0.68	0.77	5.07	4.22	11.4	22	NW
2-1-34	2300	18	1.05	0.55	0.33	0.38	0.40	0.59	0.73	1.26	1.27	1.27	2.03	1.74	0.81	0.55	0.42	4.01	2.01	12.4	20	NW
3-1-34	200	19	0.35	0.20	0.28	0.23	0.39	0.45	0.52	0.79	1.18	1.33	1.93	1.27	1.00	0.22	0.33	3.02	1.02	12.4	17	NW
4-1-34	500	19	0.32	0.31	0.29	0.30	0.45	0.85	0.72	0.94	1.32	1.58	1.45	1.02	0.69	0.42	0.32	3.21	1.07	11.4	16	NW
5-1-34	800	19	0.58	0.28	0.23	0.34	0.39	0.55	0.61	0.74	0.93	1.26	1.23	0.75	0.40	0.23	0.22	2.62	0.85	12.6	9	NW
6-1-34	1100	19	0.71	0.59	0.57	0.42	0.51	0.53	0.52	0.88	0.76	0.97	1.01	0.65	0.45	0.23	0.25	2.40	0.75	12.4	12	W
7-1-34	1400	19	0.49	0.39	0.62	0.40	0.48	0.38	0.52	0.52	0.34	0.75	0.55	0.45	0.31	0.20	0.15	1.37	0.43	11.4	15	W
8-1-34	1700	19	0.34	0.47	0.55	0.46	0.27	0.38	0.55	0.46	0.55	0.71	0.53	0.25	0.21	0.19	0.14	1.83	0.42	12.4	5	SW
9-1-34	2000	19	0.46	0.63	0.59	0.50	0.44	0.41	0.53	0.63	0.83	0.74	0.50	0.23	0.17	0.13	0.12	2.05	0.53	10.5	8	SW
10-1-34	2300	19	0.63	0.53	0.72	0.93	0.70	0.34	0.55	0.67	0.73	0.50	0.41	0.25	0.21	0.13	0.12	2.22	0.42	10.5	5	W
11-1-34	200	20	0.97	0.41	0.50	0.72	0.75	0.37	0.65	0.69	0.56	0.66	0.35	0.24	0.21	0.20	0.18	2.32	0.67	11.6	15	NW
12-1-34	500	20	0.95	0.30	0.42	0.53	0.64	0.79	0.66	0.28	0.30	0.41	0.40	0.25	0.15	0.14	0.14	2.23	0.62	9.10	13	NW
13-1-34	800	20	0.96	0.41	0.35	0.43	0.55	0.68	0.80	0.93	0.51	0.41	0.42	0.25	0.21	0.15	0.15	2.13	0.57	9.75	14	NW
14-1-34	1100	20	0.91	0.41	0.34	0.35	0.47	0.45	0.58	0.77	0.73	0.60	0.49	0.31	0.23	0.17	0.14	2.02	0.51	9.75	19	NW
15-1-34	1400	20	0.82	0.34	0.29	0.32	0.45	0.53	0.89	1.10	0.69	0.42	0.45	0.32	0.21	0.12	0.16	2.12	0.55	9.75	10	NW
16-1-34	1700	20	1.11	1.03	0.45	0.42	0.37	0.45	0.73	0.93	0.60	0.59	0.30	0.23	0.10	0.15	0.12	2.42	0.73	9.13	15	NW
17-1-34	2000	20	1.01	0.55	0.35	0.41	0.40	0.47	0.72	1.04	0.37	0.42	0.41	0.27	0.20	0.15	0.11	2.23	0.42	9.35	13	NW
1-2-34	2300	20	1.05	0.55	0.27	0.30	0.31	0.40	0.52	0.35	1.19	0.63	0.45	0.21	0.13	0.11	0.11	1.66	0.29	10.5	15	NW
2-2-34	200	21	0.62	0.26	0.24	0.32	0.31	0.45	0.59	0.73	0.76	0.65	0.29	0.20	0.14	0.09	0.14	1.75	0.33	9.75	22	NW
3-2-34	500	21	0.71	0.22	0.27	0.35	0.25	0.30	0.42	0.73	0.82	0.32	0.30	0.20	0.15	0.10	0.10	1.50	0.32	10.5	11	NW
4-2-34	800	21	1.08	1.75	0.71	0.35	0.33	0.45	0.49	0.50	0.55	0.29	0.24	0.12	0.05	0.07	0.12	2.51	0.79	9.00	15	W
5-2-34	1100	21	1.17	1.66	0.65	0.38	0.30	0.24	0.41	0.51	0.51	0.27	0.17	0.12	0.05	0.08	0.10	2.30	0.72	3.65	23	NW
6-2-34	1400	21	1.21	0.92	0.23	0.27	0.26	0.27	0.41	0.43	0.40	0.27	0.22	0.11	0.09	0.07	0.12	1.84	0.52	2.97	21	NW
7-2-34	1700	21	0.81	0.28	0.21	0.25	0.22	0.27	0.41	0.35	0.26	0.15	0.16	0.08	0.06	0.05	0.05	1.12	0.17	3.15	16	NW
8-2-34	2000	21	0.23	0.22	0.17	0.15	0.15	0.10	0.28	0.33	0.29	0.12	0.14	0.09	0.05	0.04	0.03	1.32	0.15	10.5	12	NW
9-2-34	2300	21	0.95	0.19	0.10	0.13	0.13	0.23	0.35	0.32	0.21	0.13	0.12	0.06	0.05	0.04	0.03	1.37	0.17	2.52	11	NW
10-2-34	200	22	0.87	0.76	0.11	0.15	0.21	0.23	0.28	0.25	0.16	0.10	0.09	0.07	0.05	0.04	0.07	1.03	0.15	9.75	14	NW
11-2-34	500	22	0.68	0.12	0.12	0.15	0.15	0.20	0.20	0.19	0.21	0.12	0.11	0.06	0.05	0.04	0.05	1.08	0.10	2.23	15	NW
12-2-34	800	22	0.50	0.11	0.14	0.15	0.15	0.24	0.25	0.29	0.15	0.14	0.09	0.06	0.04	0.03	0.03	0.75	0.07	9.75	8	NW
13-2-34	1100	22	0.29	0.15	0.13	0.14	0.15	0.27	0.28	0.21	0.15	0.15	0.11	0.07	0.06	0.03	0.05	0.50	0.03	9.10	11	NW
14-2-34	1400	22	0.21	0.14	0.15	0.18	0.16	0.25	0.28	0.25	0.15	0.19	0.12	0.08	0.06	0.05	0.07	0.65	0.05	9.10	8	NW
15-2-34	1700	22	0.43	0.15	0.13	0.17	0.29	0.24	0.23	0.20	0.14	0.13	0.07	0.07	0.06	0.07	0.05	0.78	0.09	9.75	5	NW
16-2-34	2000	22	1.11	1.13	1.03	0.53	0.55	0.93	0.73	0.77	0.30	0.65	0.50	0.60	0.53	0.43	0.40	3.21	1.23	9.13	7	N
17-2-34	2300	22	0.98	1.13	0.57	0.15	0.23	0.19	0.22	0.22	0.13	0.11	0.11	0.05	0.07	0.06	0.05	1.75	0.25	3.03	13	N
18-2-34	200	23	0.52	1.05	1.27	0.73	0.31	0.19	0.13	0.17	0.16	0.12	0.12	0.12	0.09	0.05	0.08	2.12	0.56	4.64	19	NE
1-1-35	500	23	0.91	1.05	1.14	1.19	0.60	0.26	0.19	0.16	0.13	0.13	0.11	0.10	0.08	0.07	0.09	2.22	0.65	5.25	19	NE
2-1-35	800	23	0.64	0.93	1.32	1.46	0.66	0.30	0.22	0.16	0.17	0.15	0.11	0.05	0.07	0.03	0.10	2.42	0.73	5.24	16	N
3-1-35	1100	23	0.71	0.84	1.00	1.05	0.63	0.20	0.17	0.16	0.20	0.12	0.13	0.11	0.03	0.05	0.03	1.53	0.49	5.45	12	NE
4-1-35	1400	23	2.04	0.71	0.79	1.06	0.36	0.23	0.21	0.17	0.16	0.11	0.12	0.06	0.07	0.05	0.07	1.73	0.37	5.25	9	NE

Figure: 4

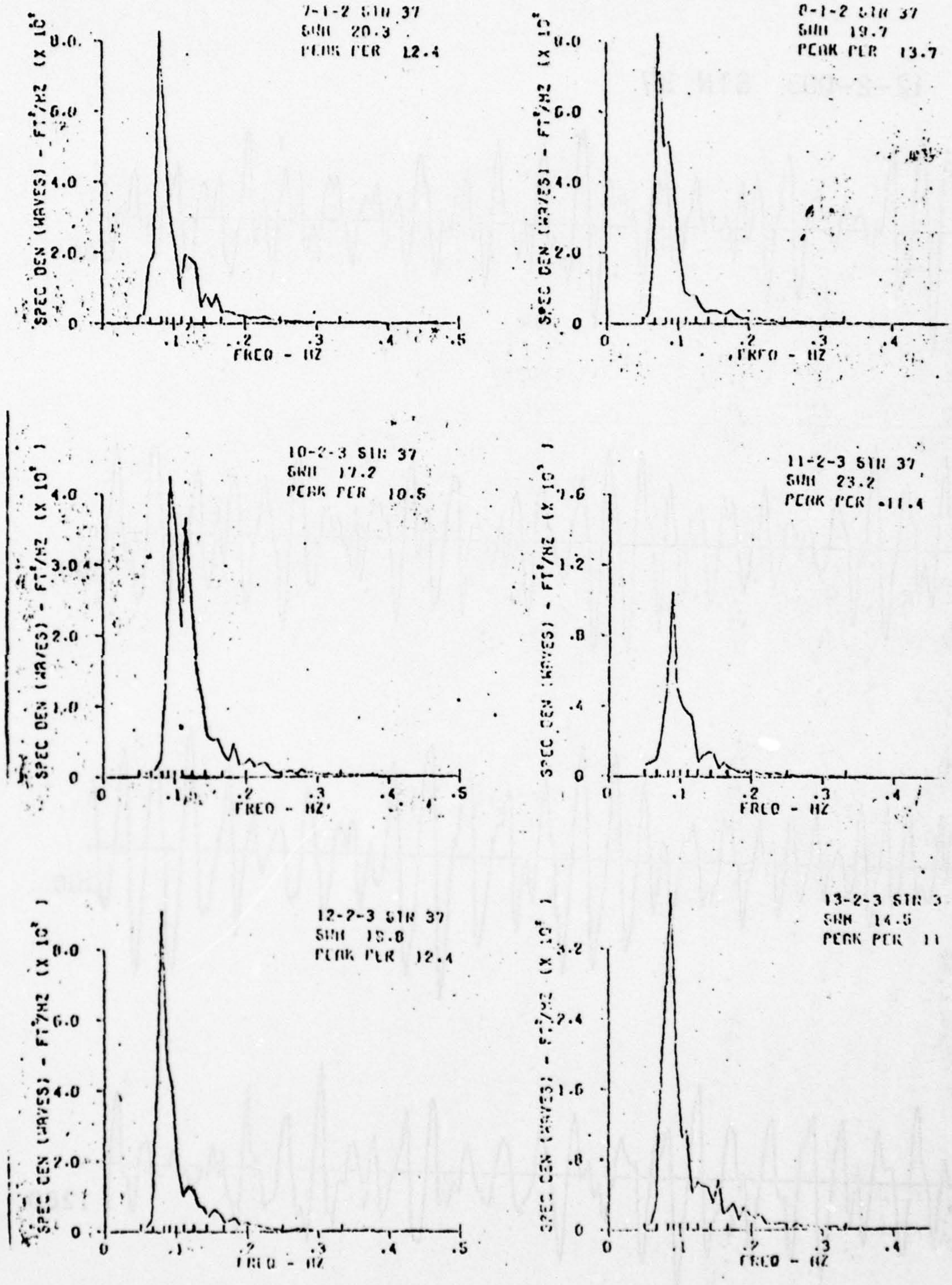
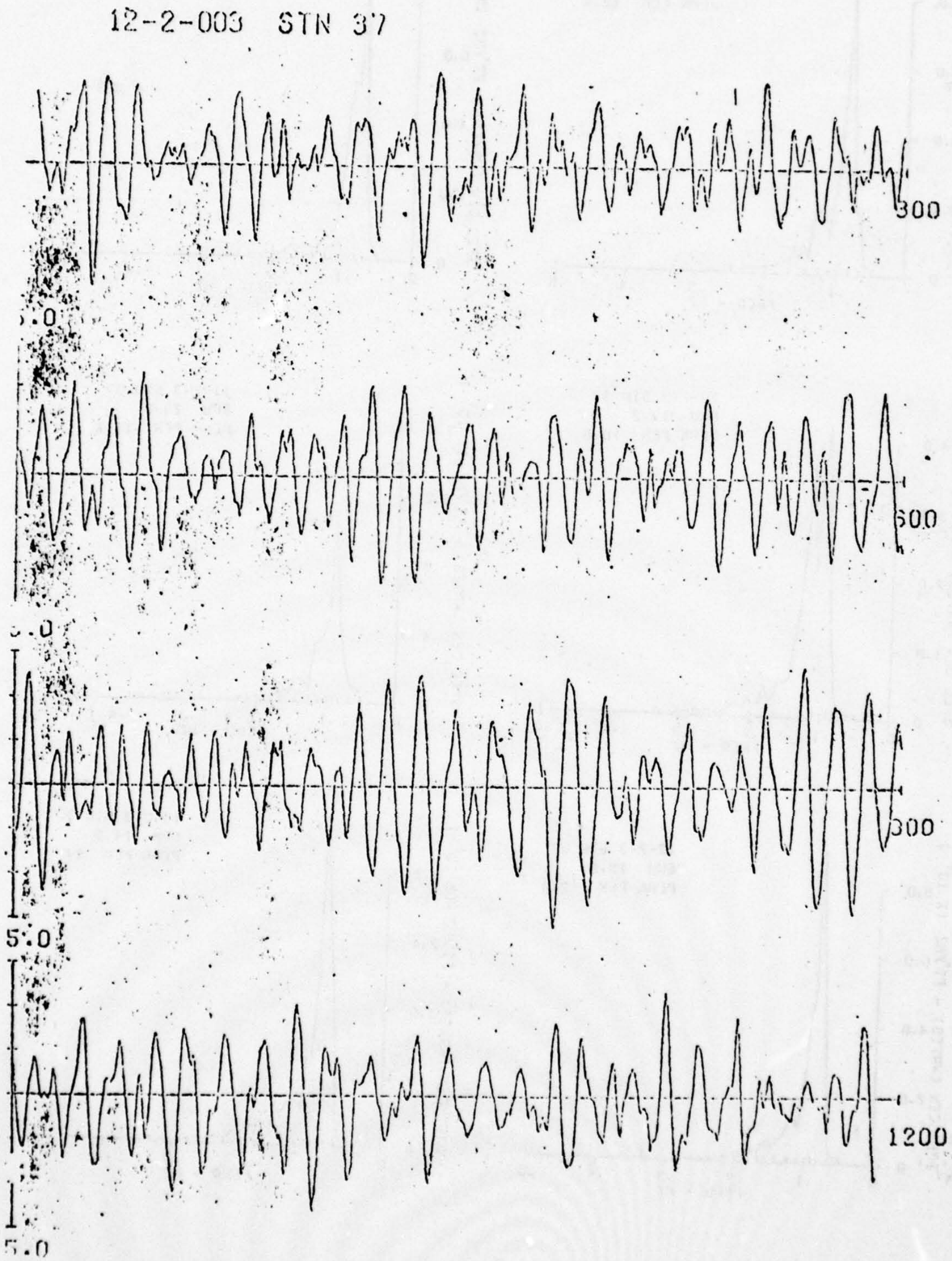

7-1-2 STN 37
SWH 20.3
PEAK PER 12.4
SPEC DEN (WAVES) - FT²/HZ (X 10³)
FREQ - HZ
8-1-2 STN 37
SWH 19.7
PEAK PER 13.7
10-2-3 STN 37
SWH 17.2
PEAK PER 10.5
11-2-3 STN 37
SWH 23.2
PEAK PER 11.4
12-2-3 STN 37
SWH 15.8
PEAK PER 12.4
13-2-3 STN 3
SWH 14.5
PEAK PER 11

Figure K


12-2-003 STN 37
5.0
300
5.0
600
5.0
900
5.0
1200
5.0

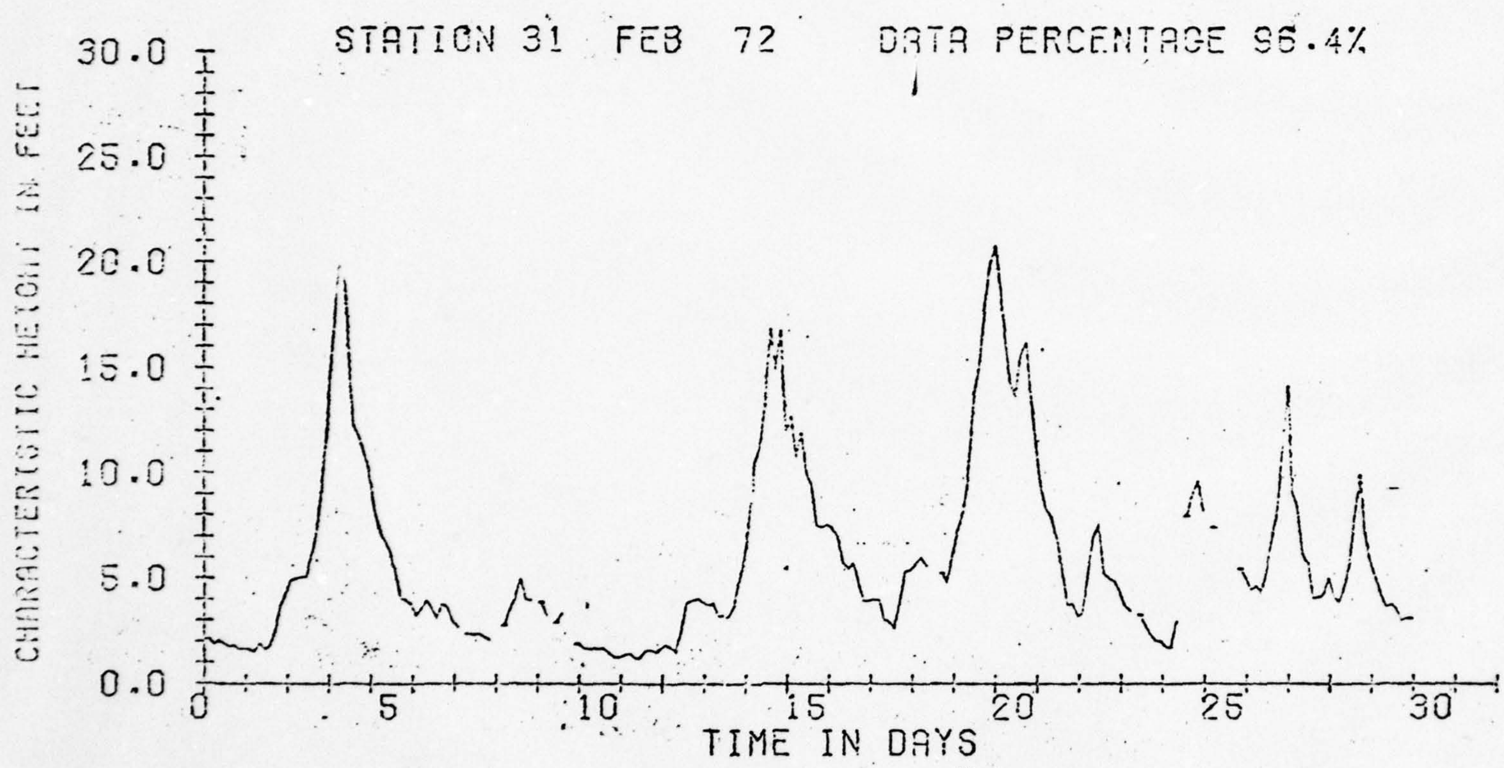

STATION 31 FEB 72 DATA PERCENTAGE 96.4%
CHARACTERISTIC HEIGHT IN FEET
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
5
10
15
20
25
30
TIME IN DAYS

Figure: 7

	ACCESSION NUMBER

DATA DOCUMENTATION FORM

NOAA FORM 24-13
(4-77)

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEANOGRAPHIC DATA CENTER
RECORDS SECTION
WASHINGTON, DC 20235

FORM APPROVED
O.M.B. No. 41-R2651
EXPIRES 1–81

(While you are not required to use this form, it is the most desirable mechanism for providing the required ancillary information enabling the NODC and users to obtain the greatest benefit from your data.)

This form should accompany all data submissions to NODC. Section A, Originator Identification, must be completed when the data are submitted. It is highly desirable for NODC to also receive the remaining pertinent information at that time. This may be most easily accomplished by attaching reports, publications, or manuscripts which are readily available describing data collection, analysis, and format specifics. Readable, handwritten submissions are acceptable in all cases. All data shipments should be sent to the above address.

A. ORIGINATOR IDENTIFICATION

THIS SECTION MUST BE COMPLETED BY DONOR FOR ALL DATA TRANSMITTALS

1. NAME AND ADDRESS OF INSTITUTION, LABORATORY, OR ACTIVITY WITH WHICH SUBMITTED DATA ARE ASSOCIATED

2. EXPEDITION, PROJECT, OR PROGRAM DURING WHICH DATA WERE COLLECTED

3. CRUISE NUMBER(S) USED BY ORIGINATOR TO IDENTIFY DATA IN THIS SHIPMENT

4. PLATFORM NAME(S)

5. PLATFORM TYPE(S) *(E.G., SHIP, BUOY, ETC.)*

6. PLATFORM AND OPERATOR NATIONALITY(IES)

PLATFORM	OPERATOR

7. DATES

FROM: MO/DAY/YR	TO: MO/DAY/YR

8. ARE DATA PROPRIETARY?

☐ NO ☐ YES

IF YES, WHEN CAN THEY BE RELEASED FOR GENERAL USE? YEAR____ MONTH____

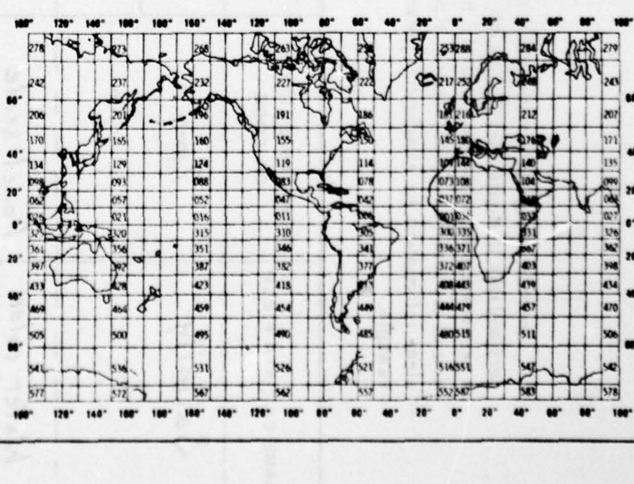
9. ARE DATA DECLARED NATIONAL PROGRAM (DNP)? (I.E., SHOULD THEY BE INCLUDED IN WORLD DATA CENTERS HOLDINGS FOR INTERNATIONAL EXCHANGE?)

☐ NO ☐ YES ☐ PART *(SPECIFY BELOW)*

10. PERSON TO WHOM INQUIRIES CONCERNING DATA SHOULD BE ADDRESSED WITH TELEPHONE NUMBER *(AND ADDRESS IF OTHER THAN IN ITEM-1)*

11. PLEASE DARKEN ALL MARSDEN SQUARES IN WHICH ANY DATA CONTAINED IN YOUR SUBMISSION WERE COLLECTED.

GENERAL AREA



B. SCIENTIFIC CONTENT

Include enough information concerning manner of observation, instrumentation, analysis, and data reduction routines to make them understandable to future users. Furnish the minimum documentation considered relevant to each data type. Documentation will be retained as a permanent part of the data and will be available to future users. Equivalent information already available may be substituted for this section of the form (i.e., publications, reports, and manuscripts describing observational and analytical methods). If you do not provide equivalent information by attachment, please complete the scientific content section in a manner similar to the one shown in the following example.

EXAMPLE (HYPOTHETICAL INFORMATION)

NAME OF DATA FIELD	REPORTING UNITS OR CODE	METHODS OF OBSERVATION AND INSTRUMENTS USED (SPECIFY TYPE AND MODEL)	ANALYTICAL METHODS (INCLUDING MODIFICATIONS) AND LABORATORY PROCEDURES	DATA PROCESSING TECHNIQUES WITH FILTERING AND AVERAGING
Salinity	‰	Nansen bottles	Inductive salinometer (Hytech model S510)	N/A (Not applicable)
		STD Bissett-Berman Model 9006	N/A	Values averaged over 5-meter intervals
Water color	Forel scale	Visual comparison with Forel bottles	N/A	N/A
Sediment size	ϕ units and percent by weight	Ewing corer	Standard sieves. Carbonate fraction removed by acid treatment	Same as "Sedimentary Rock Manual," Folk '65

(SPACE IS PROVIDED ON THE FOLLOWING TWO PAGES FOR THIS INFORMATION)

C. DATA FORMAT

This information is requested only for data transmitted on punched cards or magnetic tape. Have one of your data processing specialists furnish answers either on the form or by attaching equivalent readily available documentation. Identify the nature and meaning of all entries and explain any codes used.

1. List the record types contained in your file transmittal (e.g., tape label record, master, detail, standard depth, etc.).

2. Describe briefly how your file is organized.

3-13. Self-explanatory.

14. Enter the field name as appropriate (e.g., header information, temperature, depth, salinity.

15. Enter starting position of the field.

16. Enter field length in number columns and unit of measurement (e.g., bit, byte, character, word) in unit column.

17. Enter attributes as expressed in the programming language specified in item 3 (e.g., "F 4.1," "BINARY FIXED (5.1)").

18. Describe field. If sort field, enter "SORT 1" for first, "SORT 2" for second, etc. If field is repeated, state number of times it is repeated.

C. DATA FORMAT

COMPLETE THIS SECTION FOR PUNCHED CARDS OR TAPE, MAGNETIC TAPE, OR DISC SUBMISSIONS.

1. LIST RECORD TYPES CONTAINED IN THE TRANSMITTAL OF YOUR FILE
GIVE METHOD OF IDENTIFYING EACH RECORD TYPE

2. GIVE BRIEF DESCRIPTION OF FILE ORGANIZATION

3. ATTRIBUTES AS EXPRESSED IN ☐ PL-1 ☐ ALGOL ☐ COBOL ☐ FORTRAN ☐ ________ LANGUAGE

4. RESPONSIBLE COMPUTER SPECIALIST:
NAME AND PHONE NUMBER ________
ADDRESS ________

COMPLETE THIS SECTION IF DATA ARE ON MAGNETIC TAPE

5. RECORDING MODE ☐ BCD ☐ BINARY ☐ ASCII ☐ EBCDIC ☐ ________	9. LENGTH OF INTER-RECORD GAP (IF KNOWN) ☐ 3/4 INCH ☐ ________
	10. END OF FILE MARK ☐ OCTAL 17 ☐ ________
6. NUMBER OF TRACKS (CHANNELS) ☐ SEVEN ☐ NINE ☐ ________	11. PASTE-ON-PAPER LABEL DESCRIPTION *(INCLUDE ORIGINATOR NAME AND SOME LAY SPECIFICATIONS OF DATA TYPE, VOLUME NUMBER)*
7. PARITY ☐ ODD ☐ EVEN	
8. DENSITY ☐ 200 BPI ☐ 1600 BPI ☐ 556 BPI ☐ 800 BPI ☐ ________	12. PHYSICAL BLOCK LENGTH IN BYTES
	13. LENGTH OF BYTES IN BITS

RECORD FORMAT DESCRIPTION

RECORD NAME ____________________

14. FIELD NAME	15. POSITION FROM - 1 MEASURED IN ______ (e.g., bits, bytes)	16. LENGTH		17. ATTRIBUTES	18. USE AND MEANING
		NUMBER	UNITS		

D. INSTRUMENT CALIBRATION

This calibration information will be utilized by NOAA's National Oceanographic Instrumentation Center in their efforts to develop calibration standards for voluntary acceptance by the oceanographic community. Identify the instruments used by your organization to obtain the scientific content of the DDF (i.e., STD, temperature and pressure sensors, salinometers, oxygen meters, velocimeters, etc.) and furnish the calibration data requested by completing and/or checking ("✓") the appropriate spaces. Add the *interval time* (i.e., *3 months*, *6 months*, *9 months*, etc.) if the fixed interval calibration cycle is checked.

INSTRUMENT TYPE (MFR., MODEL NO.)	DATE OF LAST CALIBRATION	INSTRUMENT WAS CALIBRATED BY		CHECK ONE: INSTRUMENT IS CALIBRATED					INSTRUMENT IS NOT CALIBRATED (√)
		YOUR ORGANIZATION (√)	OTHER ORGANIZATION (GIVE NAME)	AT FIXED INTERVALS (√)	BEFORE OR AFTER USE (√)	BEFORE AND AFTER USE (√)	ONLY AFTER REPAIR (√)	ONLY WHEN NEW (√)	

June 26, 1975

MINIMUM DOCUMENTATION PREFERRED WITH
THE SUBMISSION OF INSTRUMENTED CURRENT DATA
TO NODC

The purpose of this addendum to the NOAA Form 24-13 (4-72), Data Documentation Form (DDF), is to establish the minimum documentation preferred with the submission of instrumented current data to the National Oceanographic Data Center (NODC). It also provides guidance for properly recording this documentation on the DDF; or, on this sheet in the absence of reports, publications, or other products containing the desired documentation.

A. Instrument Documentation:

1. Manufacturer, instrument name and model number. (Record on DDF, Section B, third column)

2. Publication(s) providing instrument specifics. (Attach publication(s) to DDF or reference below)

   a. ______________________________

   b. ______________________________

   c. ______________________________

3. Modifications made to the instrument and resultant effects on the data. (Record on DDF, Section B, fourth column)

4. Complete the following in the space provided if other than by manufacturer's specifications.

   a. Speed Range ______________
   b. Speed Threshold ______________
   c. Speed Precision ______________
   d. Speed Accuracy ______________
   e. Inclinometer Accuracy (if not recorded, indicate so) ______________
   f. Direction Precision ______________
   g. Direction Accuracy ______________
   h. Depth Precision (if depth is not recorded, indicate so) ______________
   i. Depth Accuracy (omit if depth is not recorded) ______________

B. Observation Platform Documentation:

1. Briefly describe in the third column of Section B the type of platform (shipboard, taut surface or subsurface mooring, etc.) from which observations were taken and how the instruments were mounted (on mooring, etc.); or, reference below the publication(s) containing this information, if commonly available.

   a. ____

   b. ____

   c.

   c. ____

C. Data Recording Mode and Treatment Documentation:

Describe in detail the initial at sea instrument sensing time interval; and, the time interval between consecutive, discrete, and processed observations. For example:

1. Record on DDF, Section B, third column:

   a. Sensing period (unit of time for one at sea burst or other reading for speed, direction, temperature, etc.).

   b. Interrogation interval (interval between at sea recorded consecutive readings).

2. Record on the DDF, Section B, fifth column:

   a. Number of at sea readings used for a discrete observation as recorded on final processed data record.

   b. Resultant time interval between consecutive processed observations.

   c. Method of determining final discrete observation (averaging technique).

   d. Method of summarizing if data summary is provided. Include number of observations, time interval between observations, period of time to which summary applies, applicable statistical methods, etc.

   e. Specific data editing and processing (smoothing and filtering) procedures, corrections applied (for vertical and/or horizontal oscillations, tilt angles, etc.).

   f. Method of determining platform motions.

D. Other Documentation Affecting Data Quality (record in column five DDF Form)

Specify and describe environmental conditions (waves, fouling, tidal affects, etc.) which may have a bearing on the final quality of the data.

Title 15—Commerce and Foreign Trade

CHAPTER IX—NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, DEPARTMENT OF COMMERCE

PART 950—ENVIRONMENTAL DATA

Type and Availability of Services and Information Available From Environmental Data Service

AGENCY: National Oceanic and Atmospheric Administration.

ACTION: Final rule.

SUMMARY: The information that follows describes the type and availability of environmental data, information, and assessment services that may be obtained from the Environmental Data Service for use by Federal, State, and local agencies, and the general public, including those segments engaged in commerce, industry, science, and engineering.

DATES: This rule becomes effective May 20, 1977.

FOR FURTHER INFORMATION:

An office location and phone number is provided for each type of environmental data, information, and assessment service covered by the regulation. For general information concerning the entire regulation contact Leon LaPorte at 202-634-7305.

SUPPLEMENTARY INFORMATION: (Background) The purpose of this regulation is to update the type and availability of various services, data, and information available from the Environmental Data Service. This publication supercedes regulations published on December 4, 1975 (40 CFR 56653), which are presently codified in 15 CFR, Part 950. The republication of this part is necessary to better conform the part with the services, data, and information available.

These regulations are general statements of agency policy, organization practice, and procedure, and are adopted without notice of proposed rulemaking and an accompanying comment period as provided by 5 U.S.C. 553(b)(A). The effective date of the regulations has been shortened to the date of publication as provided for in 5 U.S.C. 553(d)(2).

INFLATIONARY IMPACT STATEMENT: The National Oceanic and Atmospheric Administration has determined that this document does not contain a major proposal requiring preparation of an Economic Impact Statement under Executive Orders 11821 and 11949 and OMB Circular A-107.

ROBERT M. WHITE,
Administrator.

MAY 16, 1977.

Part 950 is revised to read as follows:

AUTHORITY: (5 U.S.C. 552, 553). Reorganization Plan No. 4 of 1970.

§ 950.1 Scope and purpose.

This part describes the Environmental Data Service (EDS), a principal organization element of the National Oceanic and Atmospheric Administration and EDS management of environmental data and information.

§ 950.2 Environmental Data Service (EDS).

The Environmental Data Service is the first Federal agency created specifically to manage environmental data. EDS disseminates worldwide environmental (aeronomy, atmospheric, marine, solar, and solid earth) data and information for use by commerce, industry, the scientific and engineering community, and the general public as well as by Federal, State, and local governments. It also provides experiment design and data management support to large-scale environmental experiments; assesses the impact of environmental fluctuations on food production, energy production and consumption, and environmental quality; and manages or provides functional guidance for NOAA's scientific and technical publication and library activities. In addition, EDS operates related World Data Center-A subcenters and participates in other international data and information exchange programs. To carry out this mission, EDS operates a network of specialized service centers and a comprehensive referral service.

§ 950.3 National Climatic Center (NCC).

The National Climatic Center disseminates climatological data; develops analytical and descriptive products to meet user requirements; and provides facilities for the World Data Center-A (meteorology and Nuclear Radiation). It is the collection center and custodian of all United States weather records, the largest of the EDS center, and the largest climatic center in the world:

(a) Climatic data available from NCC include:

(1) Hourly Surface Observations from Land Stations (ceiling, sky cover, visibility, precipitation or other weather phenomena, obstructions to vision, pressure, temperature, dew point, wind direction, wind speed, gustiness).

(2) Three-Hourly and Six-Hourly Surface Observations from Land Stations, Ocean Weather Stations, and Moving Ships (variable data content).

(3) Upper Air Observations (radiosondes, rawinsondes, rocketsondes, low-level soundings, pilot balloon winds, aircraft reports).

(4) Radar Observations (radar log sheets, radar scope photography).

(5) Selected Maps and Charts (National Meterological Center products).

(6) Derived and Summary Data (grid points, computer tabulations, digital summary data).

(7) Special Collections (Barbados Oceanographic and Meteorological Experiment meteorological data, Global Atmospheric Research Program basic data set, solar radiation data, many others).

(b) Queries should be addressed to: National Climatic Center, National Oceanic and Atmospheric Administration, Asheville, N.C. 28801. Tel. 704-258-2850 Ext. 683.

§ 950.4 National Oceanographic Data Center (NODC).

The National Oceanographic Data Center disseminates oceanographic data; develops analytical and descriptive products to meet user requirements; and provides facilities for the World Data Center—A (Oceanography). It was the first NODC established and houses the world's largest usable collection of marine data.

(a) Oceanographic data available from NODC include:

(1) Mechanical and expendable bathythermograph data in analog and digital form.

(2) Oceanographic station data for surface and serial depths, giving values of temperature, salinity, oxygen, inorganic phosphate, total phosphorus, nitrite-nitrogen, nitrate-nitrogen, silicate-silicon, and pH.

(3) Continuously recorded salinity-temperature-depth data in digital form.

(4) Surface current information obtained by using drift bottles or calculated from ship set and drift.

(5) Biological data, giving values of plankton standing crop, chlorophyll concentrations, and rates of primary productivity; also papers on marine biology.

(b) Queries should be addressed to:

National Oceanographic Data Center, National Oceanic and Atmospheric Administration, Washington, D.C. 20235. Tel. 202-634-7500.

§ 950.5 National Geophysical and Solar-Terrestrial Data Center (NGSDC).

The National Geophysical and Solar-Terrestrial Data Center disseminates solid earth and marine geophysical data as well as ionospheric, solar, and other space environment data; develops analytical, climatological and descriptive products to meet user requirements; and provides facilities for World Data Center—A (Solid-Earth Geophysics, Solar Terrestrial Physics, and Glaciology).

(a) Geophysical and solar-terrestrial data available from NGSDC include:

(1) Marine geology and geophysics. Bathymetric measurement; seismic reflection profiles; gravimetric measurements; geomagnetic total field measurements; and geological data, including data on heat flow, cores, samples, and sediments.

(2) Solar-terrestrial physics. Ionosphere data, including ionograms, frequency plots, riometer and field-strength strip charts, and tabulations; solar activity data, geomagnetic variation data, including magnetograms; auroral data; cosmic ray data; and airglow data.

(3) Seismology. Seismograms; accelerograms; digitized strong-motion accelerograms; earthquake data list (events since January 1900); earthquake data service, updates on a monthly basis.

(4) Geomagnetic main field. Magnetic survey data and secular-change data tables.

(b) Queries should be addressed to: National Geophysical and Solar-Terrestrial Data Center, National Oceanic and Atmospheric Administration, Boulder, Colorado 80302. Tel.: 303-499-1000, Ext. 6215.

§ 950.6 Center for Experiment Design and Data Analysis (CEDDA).

The Center for Experiment Design and Data Analysis provides service and support in data management and scientific analysis for large-scale environmental field research projects, and assists in the planning, design, and implementation of such projects to ensure that data needs are met.

(a) To date, CEDDA has participated in three major field experiments:

(1) BOMEX—The Barbados Oceanographic and Meteorological Experiment. BOMEX was conducted in the tropical Atlantic east of Barbados as a national, multiagency study of the behavior and interaction of the ocean-atmosphere system in subtropical and tropical waters. The complete set of data resulting from this project is available at the National Climatic Center.

(2) IFYGL—The International Field Year for the Great Lakes. IFYGL was a joint United States-Canada program of environmental research aimed at achieving more effective management of Lake Ontario water resources and at solving the water management problems posed by a growing population in the lake basin area. Most of the data resulting from this project are available at the National Climatic Center.

(3) *GATE—The Global Atmospheric Research Project (GARP) Atlantic Tropical Experiment.* GATE was a multinational research project that spanned the Atlantic Ocean and studied the equatorial atmosphere and ocean—the main heat sources driving the atmosphere's general circulation. A set of basic data from this project is available from the National Climatic Center.

(b) The Marine Assessment Division helps NOAA to meet requirements placed upon it by the Deepwater Port (DWP) Act of 1974. The Act establishes procedures for the location, construction, and operation of deepwater ports off the coasts of the United States. It invests licensing authority in the Secretary of Transportation, while the Administrator of NOAA is called upon to provide essential support. To meet NOAA's obligation, the Assessment Division reviews, evaluates, and prepares recommendations for the Administrator on DWP license applications, related environmental impact statements, and adjacent coastal State status. It has provided assessments for the Louisiana Offshore Oil Port and the SEADOCK port of Galveston, Texas. It is currently assessing the environmental aspects of storage schemes for developing national strategic petroleum reserves.

(c) Queries should be addressed to:

Center for Experiment Design and Data Analysis, National Oceanic and Atmospheric Administration, Washintgon, D.C. 20235, Tel. 202-634-7251.

§ 950.7 Environmental Science Information Center (ESIC).

The Environmental Science Information Center develops policies for and provides editorial and publishing services to NOAA components; manages a central library system; provides functional guidance to other NOAA libraries; and develops and implements automated scientific information systems for NOAA and external use.

(a) ESIC issues a "NOAA Publications Announcement" several times a month. This booklet describes NOAA publications by title, author, source, date, abstract, keywords, and availability.

(b) The NOAA libraries are open to the public for reference use. The Atmospheric Sciences Library, 8060 13th Street, Silver Spring, Maryland, specializes in climatic publications; the Marine and Earth Sciences Library, 6001 Executive Boulevard, Rockville, Maryland, in cartographic, oceanographic, and fisheries publications; the NOAA Miami Library, 15 Rickenbacker Causeway, Miami, Florida, in oceanographic, cartographic, and climatic publications; and the NOAA Environmental Research Laboratories Library, University of Colorado, Boulder, Colorado, in solar-terrestrial physics.

(c) ESIC also responds to requests for copies of NOAA technical publications by sending out those in stock or referring the request to the proper NOAA or non-NOAA source.

(d) Queries should be addressed to:

Environmental Science Information Center, National Oceanic and Atmospheric Administration, Washington, D.C. 20235. Tel. 202-634-7300.

§ 950.8 Center for Climatic and Environmental Assessment (CCEA).

(a) CCEA provides tailored assessment services and products to Federal agencies concerned with the impact of the environment on national social and economic programs and policies.

(b) CCEA is participating in the joint USDA-NOAA-NASA program called the Large Area Crop Inventory Experiment (LACIE). The aim of the LACIE experiment is to improve the timeliness and accuracy of major crop forecasts by combining current and historical, surface and satellite, crop and weather source data. CCEA develops and refines the mathematical models that relate crop yields to weather conditions and provides processed climatological and meteorological data.

(c) Special studies and consultant services are provided to government agencies along with the following products: early warning and timely crop/climate alerts, crop yield estimates on a monthly basis, global weather briefings which relate climate impact on socioeconomic systems, and risk assessments of climatological phenomena on national resources.

(d) Three different weekly assessment reports are prepared. The first, prepared for Congress, consists of a 1 or 2 page summary with accompanying map of the principal global droughts, floods, and other weather anomalies. The second, prepared for LACIE, is 30 to 60 pages and analyzes and describes the effects of the past week's weather on the major wheat

producing areas of the world outside the U.S. (i.e., Argentina, Australia, Brazil, Canada, China, India, and U.S.S.R.). The third, prepared for the State Department, is 15 to 20 pages and analyzes and describes crop weather over the seventeen country band of sub-Saharan Africa from Mauritania and Senegal in the west to Ethiopia, Somalia, and the Sudan in the east.

(e) Queries should be addressed to:

Center for Climatic and Environmental Assessment, 600 East Cherry Street, Columbia, MO 65201, Tel. 314-442-2271, Ext. 3261.

§ 950.9 Satellite Data Services Branch (SDSB).

The Satellite Data Services Branch of the EDS National Climatic Center provides environmental and earth resources satellite data to other users once the original collection purposes (i.e., weather forecasting) have been satisfied. The branch also provides photographs collected during NASA's SKYLAB missions. Available from SDSB are:

(a) Satellite data from SDSB include: (1) Data from the TIROS (Television InfraRed Observational Satellite) series of experimental spacecraft; much of the imagery gathered by spacecraft of the NASA experimental NIMBUS series; full-earth disc photographs from NASA's Applications Technology Satellites (ATS) I and III geostationary research spacecraft; tens of thousands of images from the original ESSA and Current NOAA series of Improved TIROS Operational Satellites; and both full-disc and sectorized images from the Synchronous Meteorological Satellites (SMS) 1 and 2, the current operational geostationary spacecraft. In addition to visible light imagery, infrared data are available from the NIMBUS, NOAA, and SMS satellites. Each day, SDSB receives about 239 negatives from the polar-orbiting NOAA spacecraft, more than 236 SMS-1 and 2 negatives, and several special negatives and movie film loops.

(2) Multispectral imagery derived from data collected by NASA's Earth Resources Technology Satellites (ERTS), currently LANDSAT-1 and 2.

(3) Photographs (both color and black-and-white) taken during the three SKYLAB missions (May-June, 1973, July-September, 1973, and November 1973-February 1974).

(b) Queries should be addressed to:

Satellite Data Services Branch, World Weather Building, Room 606, Washington, D.C. 20233, Tel. 301-763-8111.

§ 950.10 Comprehensive Referral Service.

The Environmental Data Index (ENDEX) provides rapid, automated referral to multi-discipline environmental data files of NOAA, other Federal agencies, state and local governments, universities, research institutes, and private industry. A complementary, literature-based system, Oceanic and Atmospheric Scientific Information System (OASIS) provides a parallel subject-author-abstract referral service. A telephone call to any EDS data or information center or NOAA library will allow a user access to this service.

[FR Doc.77-14443 Filed 5-19-77;8:45 am]

INCLOSURE 12

Summary of Presentation by
Mr. Kenneth Steele of NDBO

The NDBO recently prepared a short paper for the Ocean Wave Climate Symposium held at the Dulles Marriott near Washington D. C. in July 1977. This paper provides an overview of NDBO wave measurement activities and at this date (October, 1977) is not significantly out of date. Attached is a copy of this paper for the record.

One recent development worthy of note is that the development of Small Buoy for measuring waves only, "Waverider Analyzer Satellite Communicator (WRANSAC)," is continuing, and at-sea testing of this GOES reporting buoy is expected to begin in mid-November to December of 1977.

Effort continues to examine the quality of data being produced by NDBO's buoys already at-sea.

The NDBO has examined some of the factors to be discussed in the workshop sessions and appreciate the opportunity to participate.

U.S. DEPARTMENT OF COMMERCE ● NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

OFFICE OF OCEAN ENGINEERING

NOAA DATA BUOY OFFICE

NDBO WAVE MEASUREMENTS

JULY 1977

NDBO WAVE MEASUREMENTS

by

Kenneth Steele
Andrew Johnson, Jr.

I. DESCRIPTION OF WAVE MEASUREMENT SYSTEMS

The NOAA Data Buoy Office (NDBO) is acquiring wave measurements from a number of ocean stations, the locations of which are shown in Figure 1. The stations fall into three categories; deep ocean stations, continental shelf stations, and an experimental station. The deep ocean stations and the continental shelf stations routinely report wave data to users. Data from two payloads aboard a buoy at the experimental station are used for development purposes, and are not normally reported to users.

Figure 2 contains a table that shows the types of systems used at these stations. A variety of combinations of platforms, sensors, sensor mountings, signal conditioning, data processing techniques and data are embodied in the NDBO systems that routinely report wave data. This variety of combinations has arisen due to the necessity of making use of existing hulls and payloads.

The earliest system developed, of those appearing in Figure 2, is the "Engineering Experimental Phase" *(EEP) system*, which has been described in a paper[1] published in 1975. This system has performed well when it was working despite the relatively high noise levels associated with it. However, the hardware was not operationally reliable and the NDBO now has only one such system at sea. It is being used to evaluate the performance of more advanced systems.

The type of wave measurement hardware most used by the NDBO at this time is the Wave Spectrum Analyzer (WSA). The WSA[2], in two slightly different hardware configurations, can be used with either the "Limited Capability Buoy" (LCB) payload, or with the "Prototype Environmental Buoy" (PEB) payload. A schematic diagram of the system is shown in Figure 3. The WSA consists of 12 separate parallel analog filters, each of which has adjustable center frequency, bandwidth, and gain. An accelerometer's output is fed into each filter. The near-DC output voltages from the channels are sampled and the mean values of these samples are sent to shore where the heave displacement of the sea surface is reconstructed.

Figure 4 shows the power gain curves for the 12 filters, each normalized to unity at the center frequency. The near-DC voltage output of each filter is the result of the product of the frequency-dependent filtering function and the voltage spectrum. The voltage output of a filter will be very nearly proportional to the spectral density only in those cases where the bandwidth of the filter is very small compared to the variation of the spectrum near the center frequency. However, the entire spectrum cannot be covered effectively with only 12 very narrow filters. Furthermore, narrow band filters have a tendency to be unstable. Therefore, the WSA does not use very narrow filters.

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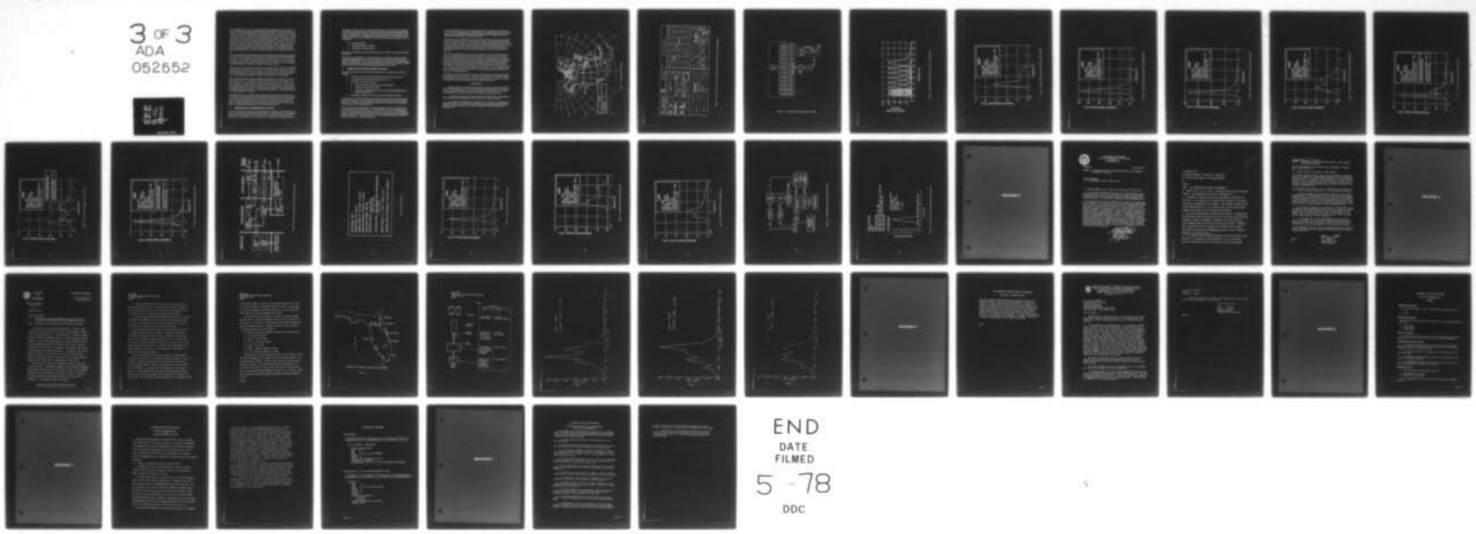

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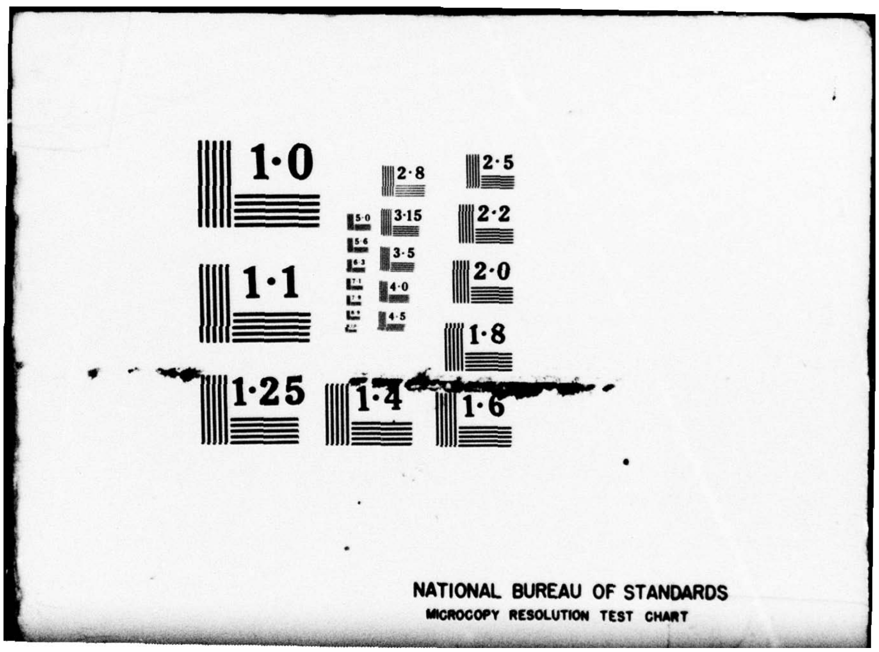
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1·8
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1·6
NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

If the bandwidths of the filters are made relatively large, then the skirts of each filter, in which the spectral density may be very different from the spectral density at the center frequency, will contribute significantly to the output of the filter. To compensate for the spectral density errors that normally occur due to the filter skirts, the frequency axis is divided into contiguous intervals equal to the filter bandwidths and centered on the filters. The voltage output of each filter is then assumed to be made up of contributions made separately by each interval. This analytical approach leads to the voltage from each filter, and the count produced from it by the A to D converter, being expressed approximately as a linear sum of the (unknown) spectral densities at the center of each filter. These 12 equations in 12 unknowns are solved simultaneously to produce 12 new equations, each of which relates one spectral density to all 12 of the counts produced by the filters. It is from these equations that the spectral densities are produced. Figures 5 through 8 show examples of WSA type data.

Some informal Waverider experiments have been performed to verify the basic performance of the WSA systems deployed, and the results of these experiments are shown in Figures 9, 10, and 11. These experiments were informal to the extent that the Waverider, which was assumed to be accurate, was not precisely calibrated, and no attempt was made to improve the performance of the WSAs based on the Waverider data. The NDBO is actively engaged in an effort to perform an end-to-end calibration of the WSA systems.

Although the WSA type systems are generally reliable and produce useful data, their spectral range and resolution leave much to be desired. It is NDBO's intent to replace those in service with superior systems as soon as possible. Since the WSAs were produced in response to the need for systems that would be compatible with payloads that had only analog interfaces, the retirement of the WDAs will depent on the retirement of these payloads.

The most advanced type of system in the NDBO wave measurements inventory is the Wave Data Analyzer (WDA). This system has been described in detail in a recent paper.[3] The WDA consists of a vertically mounted accelerometer whose output voltage is filtered, sampled and transformed on-board the buoy into the equivalent of covariances. Figure 12 contains a system schematic of the WDA, and Figure 13 shows the key spectral parameters for two different variations of the WDA. The data produced by the WDA are telemetered by the buoy payload to shore where they are transformed into the spectrum. Examples of these data are shown in Figures 14, 15, and 16.

Although the NDBO is very confident that the WDA reports quality data, this assertion has not yet been proven by systematic calibrations against calibrated ground truth measurements. The reason that really good calibrations of WDAs have not yet been performed is that until recently no great demand by the user community for high accuracy has been perceived by NDBO. In recent months interest in wave data has risen and the NDBO has attached a high priority to upgrading the calibrations of both the WDAs and the WSAs.

II. COMMUNICATION AND DISSEMINATION OF THE DATA

Spectral wave data are acquired by each operational buoy every three hours at standard synoptic times (hourly data are available from some buoys). Within 30 minutes after the synoptic hour, the data are transmitted via HF to NDBO's Shore Collection Station (SCS) in Miami (Figure 17). At SCS these data are coded and used to compute spectral densities of vertical

displacement of the sea surface. These spectral densities are used to calculate significant wave height and average wave period. These are sent to the National Meteorological Center (NMC) via teletype along with meteorological data obtained from the buoy in standard ship's weather message format. The displacement spectral densities are then coded into a special format (Figure 18) for transmission from SCS to NMC for further dissemination to users involved with:

- Marine forecasting
- Operational forecast verification
- Development of forecast models

Once each day SCS sends all raw and processed buoy data to NDBO for evaluation and further processing.

All data from the operational buoys are examined for time continuity, internal consistency, and synoptic representativeness. Reports of the status of all operational data are mailed weekly to interested users. When errors are detected in the data, they are flagged on NDBO's data base and deleted from archival tapes which are prepared monthly and sent to the National Climatic Center (NCC) and the National Oceanographic Data Center (NODC).

III. PRESENT AND FUTURE DEVELOPMENT ACTIVITIES

The NDBO's present and future development activities can be classified into the following categories:

- Reduction of Procurement and Operating Costs for Every Type System
- Development of Small Buoy for Measuring Waves Only
- Improvement of Routine Operations:
  - Improvement of the Calibrations of Each Type System
  - Retirement of WSA When Possible
  - Procurement and Deployment of more One Dimensional Spectral Wave Measurement Systems
- Development of Systems to Measure Directional Properties of the Sea

An important part of NDBO's future development efforts is the reduction of the cost of wave measurement systems. It seems clear that at least some progress can be made in reducing these costs. The WDA's have cost approximately $10K, and it is believed that a significant reduction in this cost is an achievable goal.

One form of the cost reduction effort is an attempt to develop a small, easy to handle, buoy that will report only wave measurements. A Waverider buoy is now being modified (under a contract to the Government) to report spectral wave data via the GOES. The configuration of this buoy, which has been named the Waverider Analyzer Satellite Communicator (WRANSAC), is shown in Figure 2. A small buoy of this type, if successfully developed, has great flexibility and can serve in a variety of applications.

One such application is that of serving as ground truth for the calibration efforts that will from now on be a continuing activity. With the help of the WRANSAC and conventional Waveriders, better hull transfer functions and noise corrections will be determined, and the quality of wave data will be systematically improved.

Another key element in NDBO's present and future activities is the development of systems to measure directional spectra, or to measure some other of the directional properties of the sea. This effort is well underway, and there is optimism that measures of the directional character of the sea can be successfully developed and implemented operationally at a cost only slightly greater than that for one dimensional spectra. It is the intent of NDBO to implement buoys capable of measuring directional properties of the sea in the next two to four years.

The NDBO has achieved some success in the verification of wave measurements from one buoy by correlating them with measurements from one or more other buoys in the ocean area. The results indicate that more wave information can be extracted from a network of buoys than can be derived from the same buoys treated as individual measurement stations. The NDBO is now evaluating the feasibility and desirability of systematically correlating measured wave data to monitor the proper functioning of hardware on individual buoys. Conceptually, it seems likely that the spectral wave data collected from a network of buoys in an area (such as the Gulf of Alaska) could be used to produce a report of conditions in the area. The NDBO encourages data users to consider introducing a network approach into their wave forecasting procedures.

The NDBO's future wave measurements program comprises the categories listed on page 3. The symposium for which this paper is written will be most helpful to the NDBO if a better understanding of the needs of the user community can be achieved. This in turn should lead to an improved plan for the development of wave measurement systems.

REFERENCES

1. Kenneth E. Steele; J. Michael Hall; and Frank X. Remond, "Routine Measurements of Heave Displacement Spectra from Large Discus Buoys in the Deep Ocean," Proceedings of the First Combined IEEE Conference on Engineering in the Ocean Environment and the Annual Meeting of the Marine Technology Society (OCEAN 75), September 1975.

2. F. X. Remond, "Ocean Spectrum Measurement with Analog Filters," Proceedings of 22nd International Instrumentation Symposium, May 1976, San Diego, California.

3. K. E. Steele, P.A. Wolfgram, A. Trampus, and B. S. Graham, "An Operational High Resolution Wave Data Analyzer System for Buoys," Proceedings of the Second Annual Combined Conference Sponsored by The Marine Technology and the IEEE (Ocean '76), September 1976.

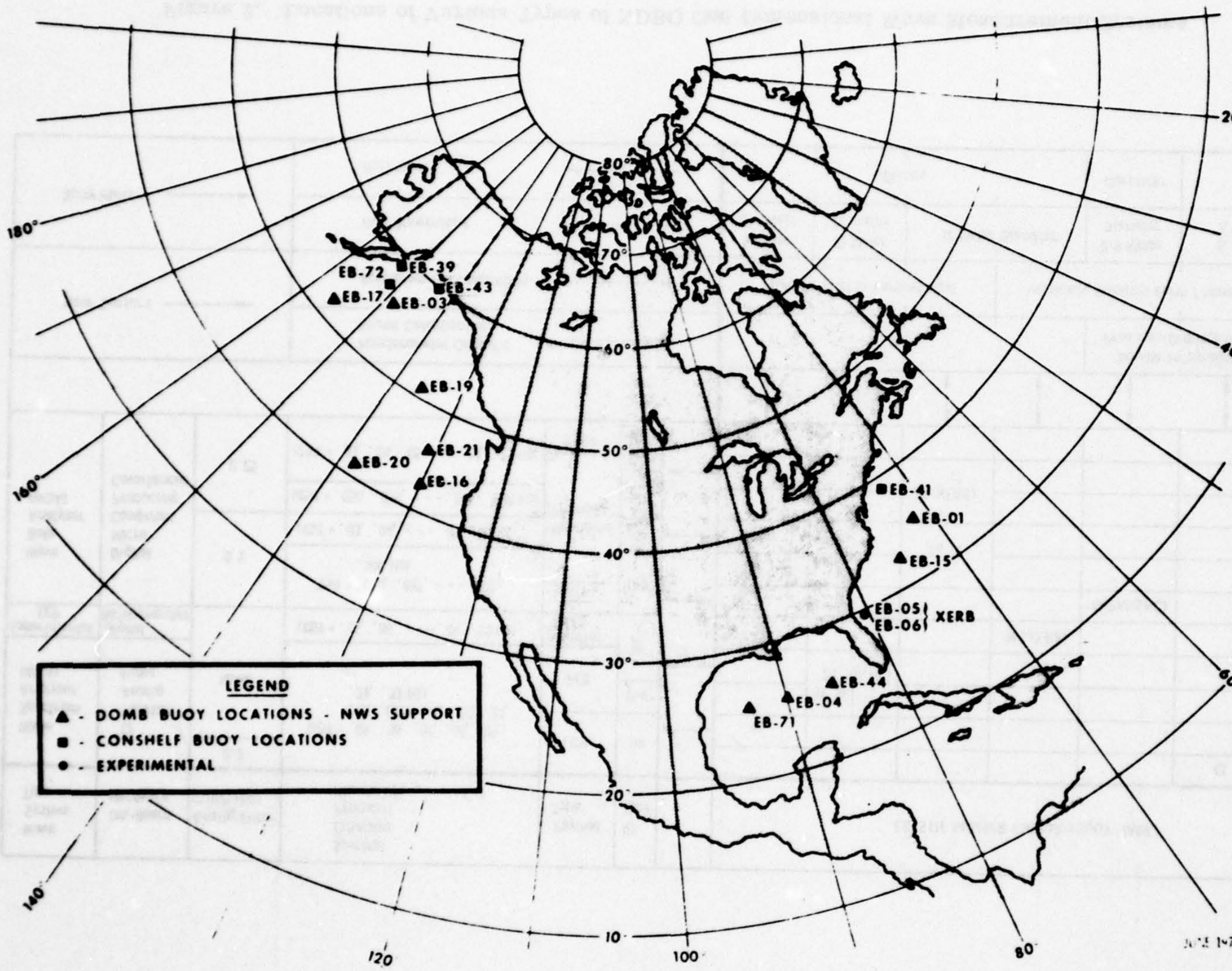


Figure 1. Wave Measurement Stations

Wave System Type	On-Board Hardware	Analog Filter Cutoff (Hz)	Spectral Estimates Produced (Number/f=, , - - - Hz)	Payload Type	RF Type	EB-SITE NUMBER AND/OR (BUOY NAME)
Wave Spectrum Analyzer (WSA)	12 Parallel Analog Filter	0.3	(12/f = .05, .06, .07, .08, .09, .10, .1225, .16, .20, .24, .28, .33 Hz)	LCB	HF	41; 43; 39
		None		PEB	UHF	01, 19 20
					HF	03, 16, 17 15, 07
Experimental EEP	Digital Minicomputer		(48/f = .03, .04, - - - .49, .50 Hz)	Modified EEP	HF	06 (XERB)
Wave Data Analyzer (WDA)	Digital Micro Computer Producing Covariances	0.5	(95/f = .030, .035, - - - .495, .500 Hz)	GDTT	UHF	(WRANSAC)
			(49/f = .03, .04, - - - .49, .50 Hz)	Magnovox Phase II	HF	71, 72; 04, 44
		0.25	(45/f = .030, .035, - - - .245, .250 Hz)		UHF	
			(23/f = .03, .04, .05 - - - .24, .25 Hz)		HF	05 (XERB)
				CSBP	UHF	

Wave Sensors	Accelerometer Output's Signal Conditioning	None		Double Integration Produces Displacement	None
	Accelerometer's Mounting	Fixed Parallel to Vertical Mast	Vertically Stablized Earth Frame		Fixed II to Mast
Buoy Hulls	Hull Dimensions	5 Meter Diameter; 10 Meter Diameter	12 Meter Diameter	0.9 Meter Diameter	6.22 Meter Length 2.95 Meter Beam
	Hull Type	Discus		Woverider	NOMAD (Boat Shape)

Figure 2. Locations of Various Types of NDBO One Dimensional Wave Measurement Systems

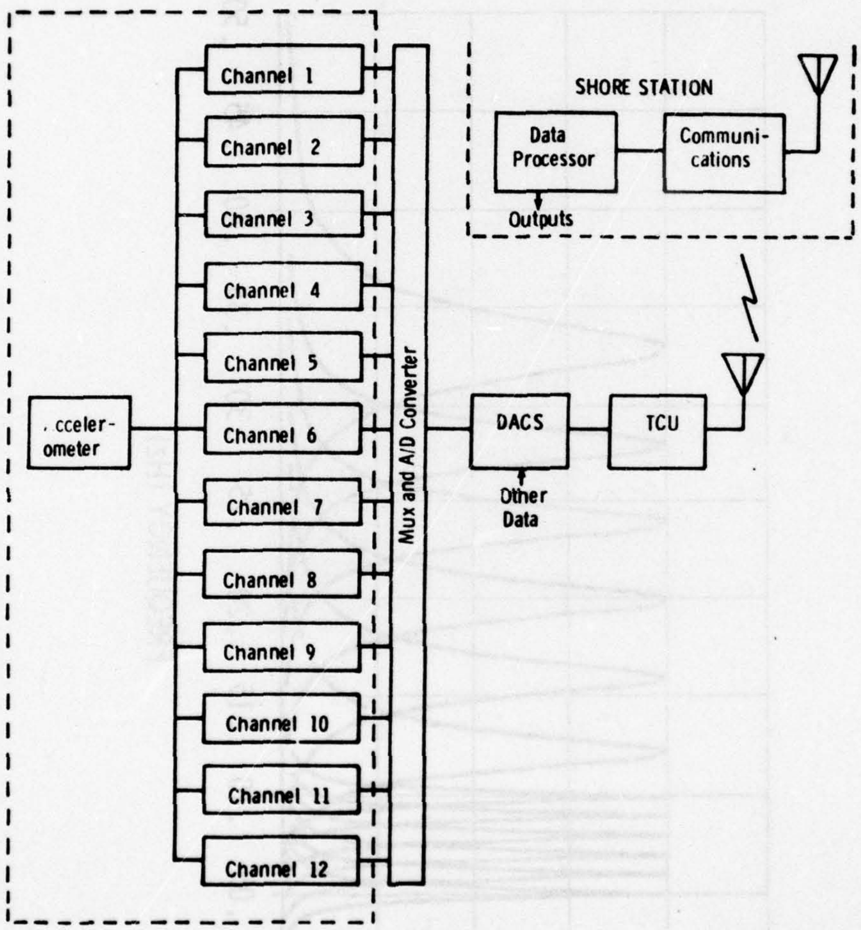


Figure 3. Wave Spectrum Analyzer System Schematic

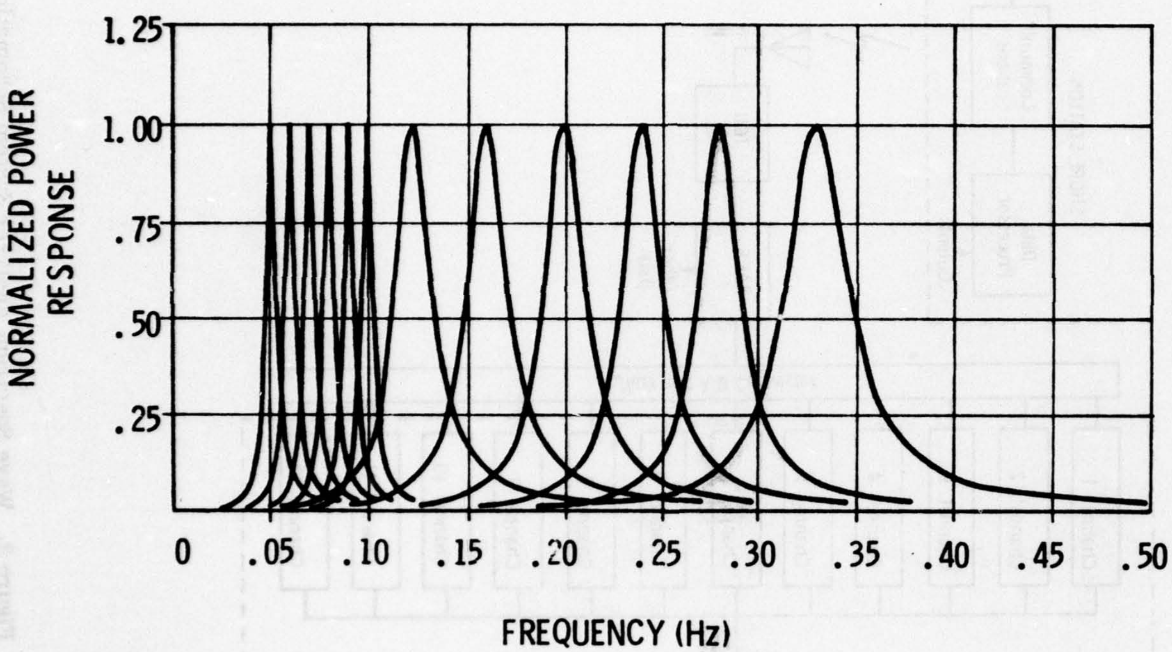


Figure 4. Normalized Filter Response Curves for 12 Channel WSA

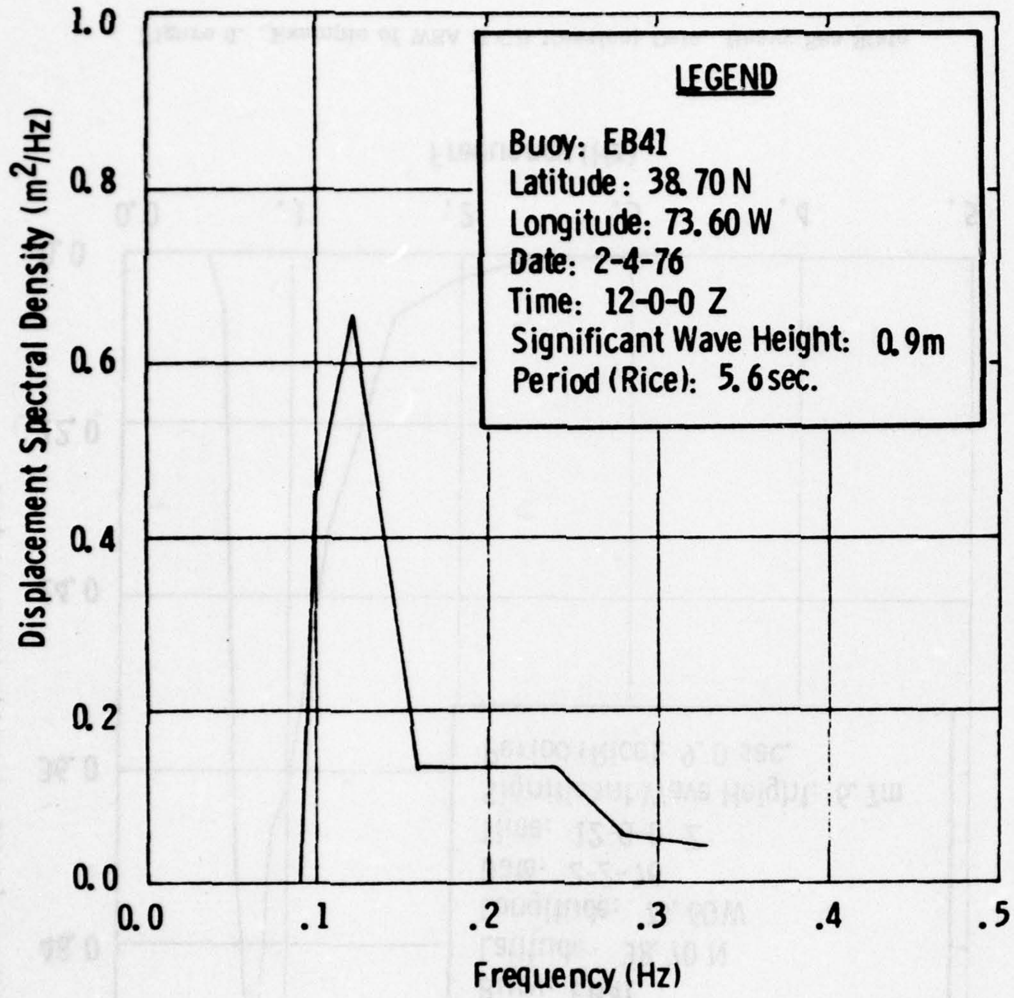


Figure 5. Example of WSA (LCB Version) Data, Light Sea State

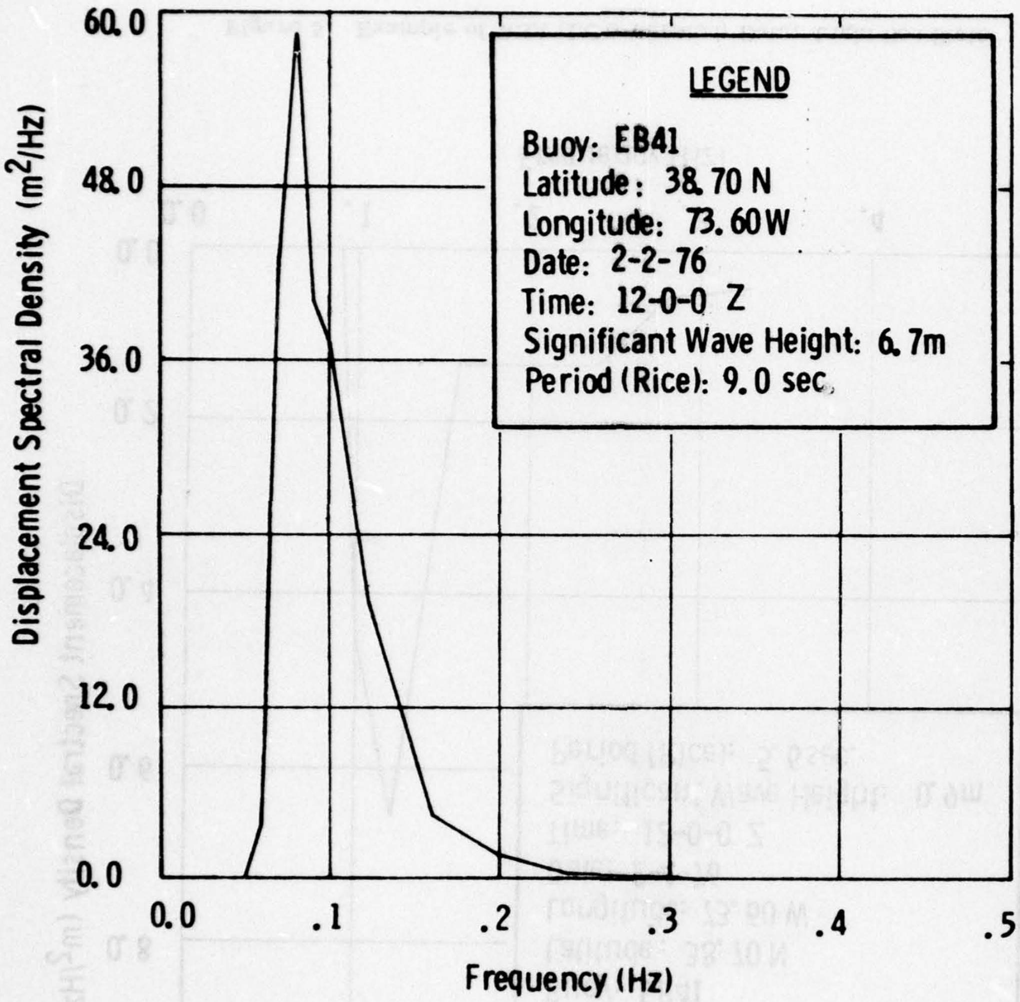


Figure 6. Example of WSA (LCB Version) Data, Heavy Sea State

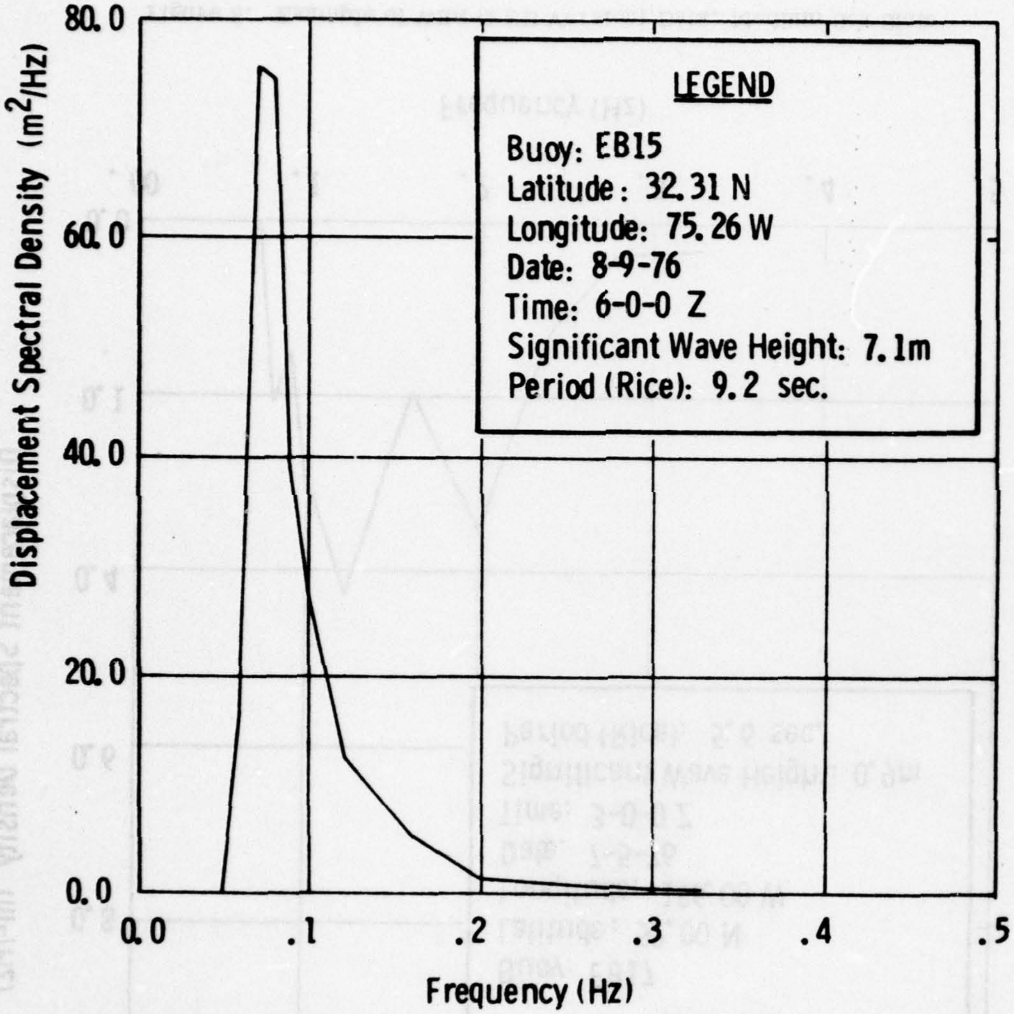


Figure 7. Example of WSA (PEB Version) Data, Heavy Sea State

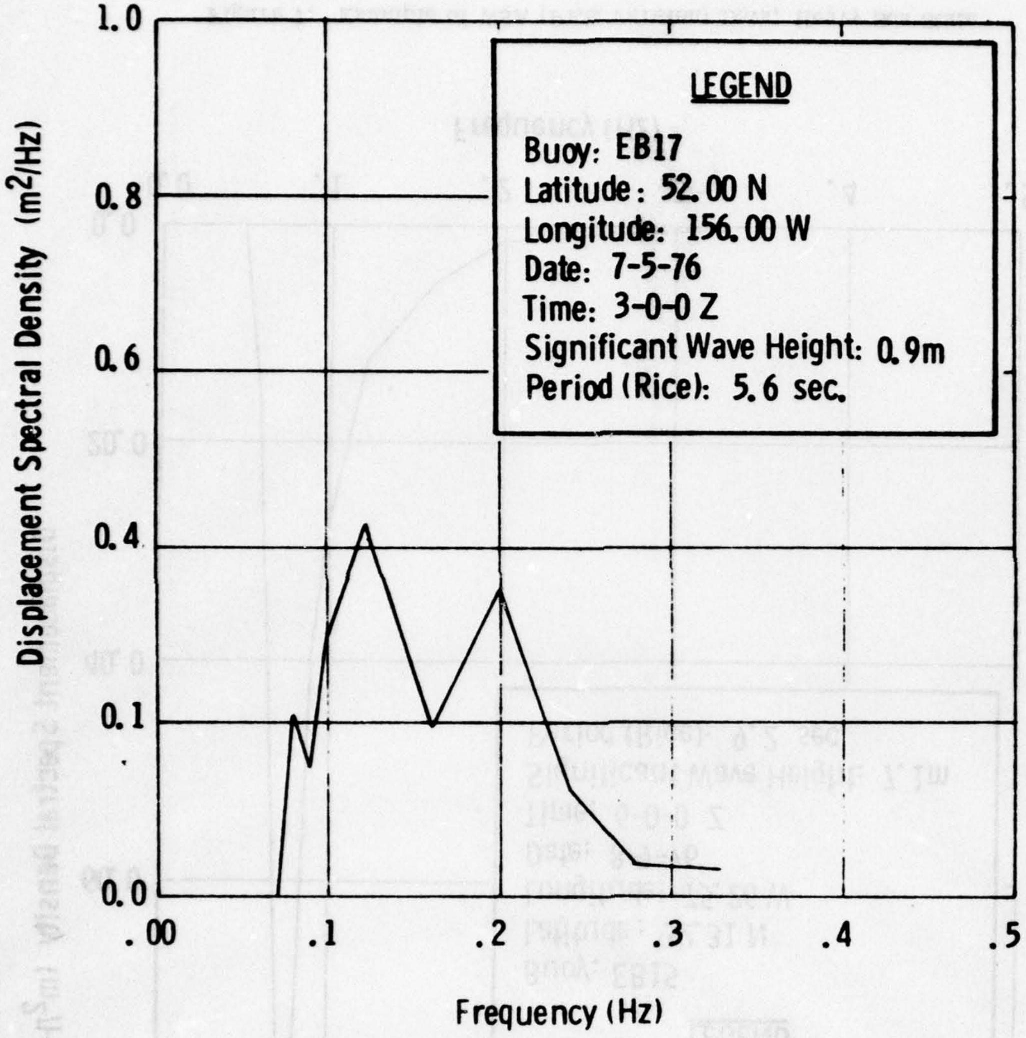


Figure 8. Example of WSA (PEB Version) Data, Medium Sea State

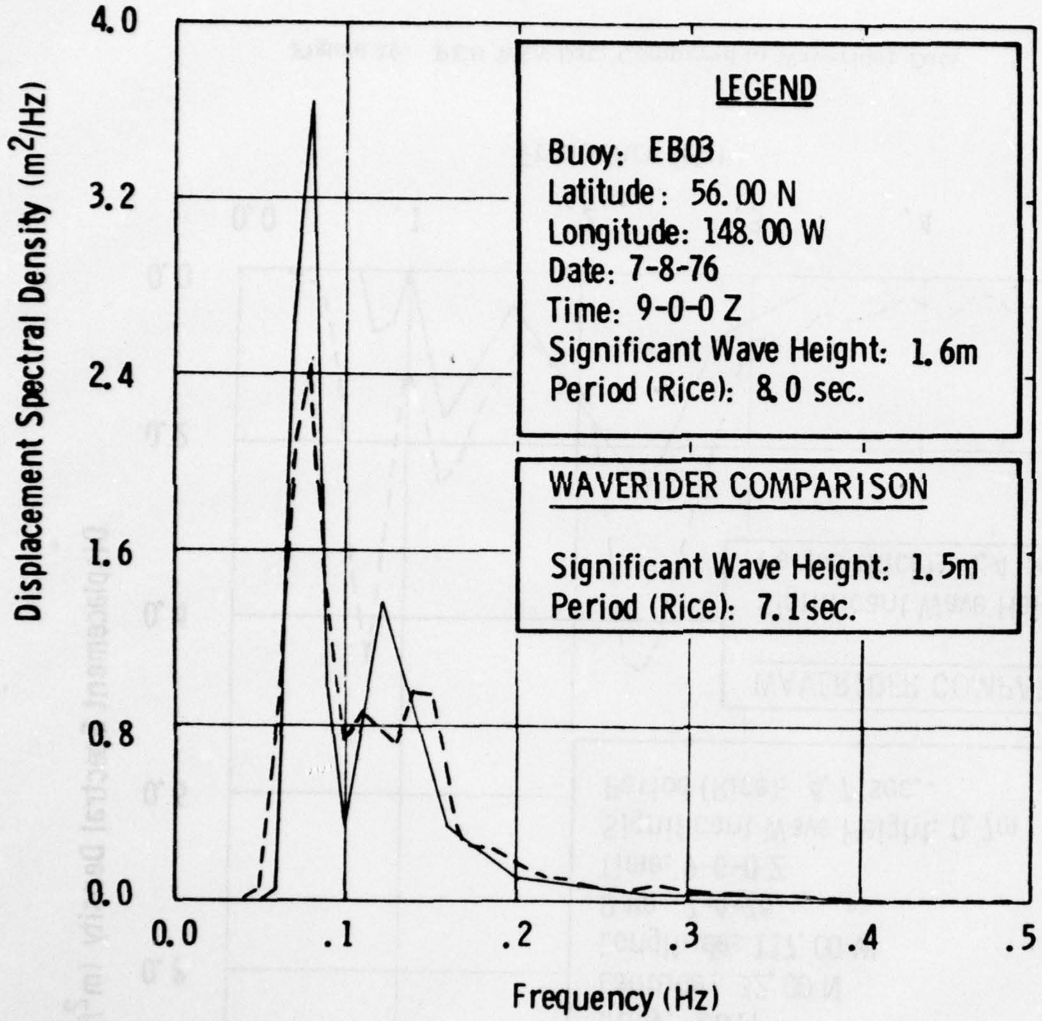


Figure 9. PEB WSA Data Compared to Waverider Data

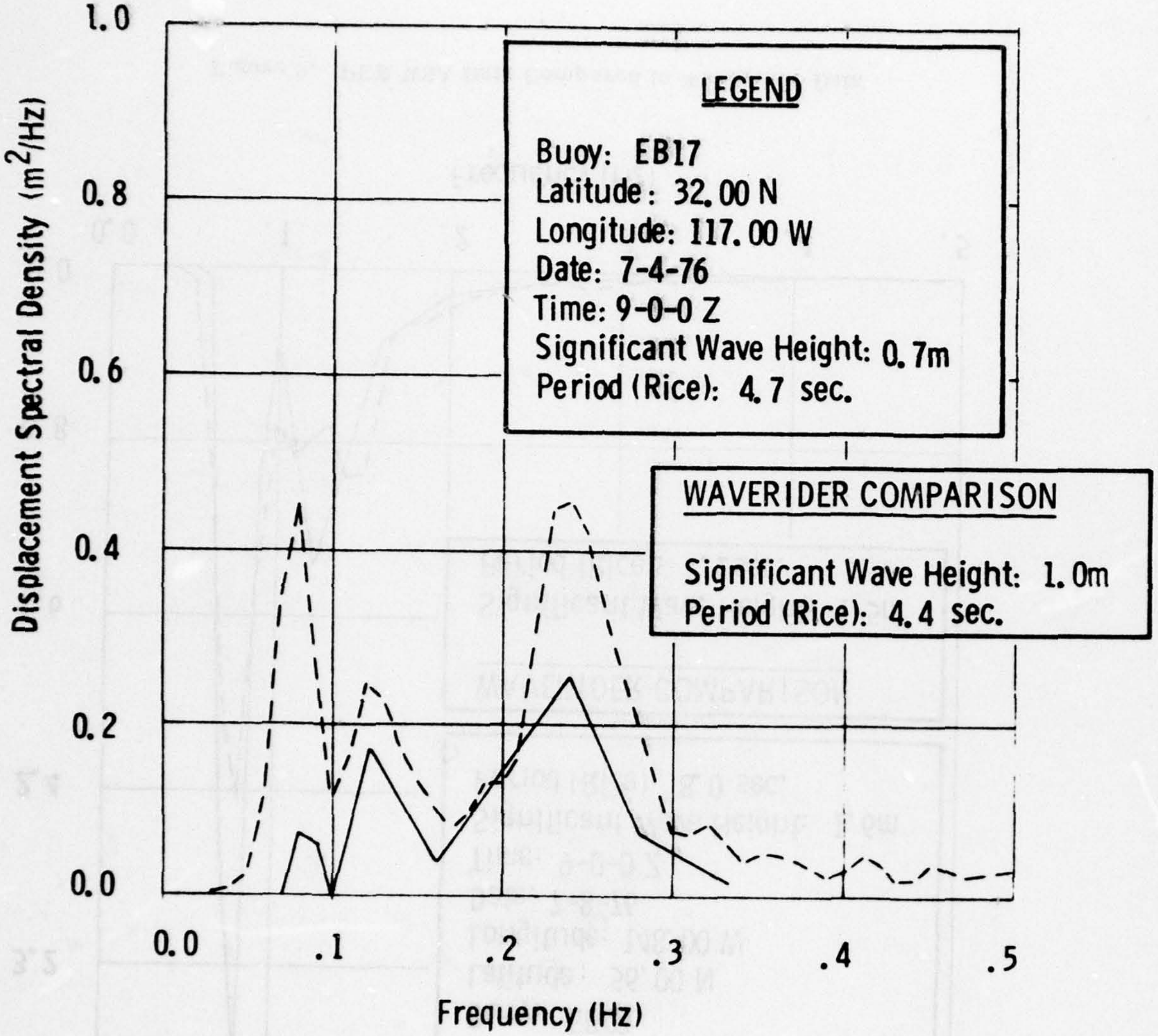


Figure 10. PEB WSA Data Compared to Waverider Data

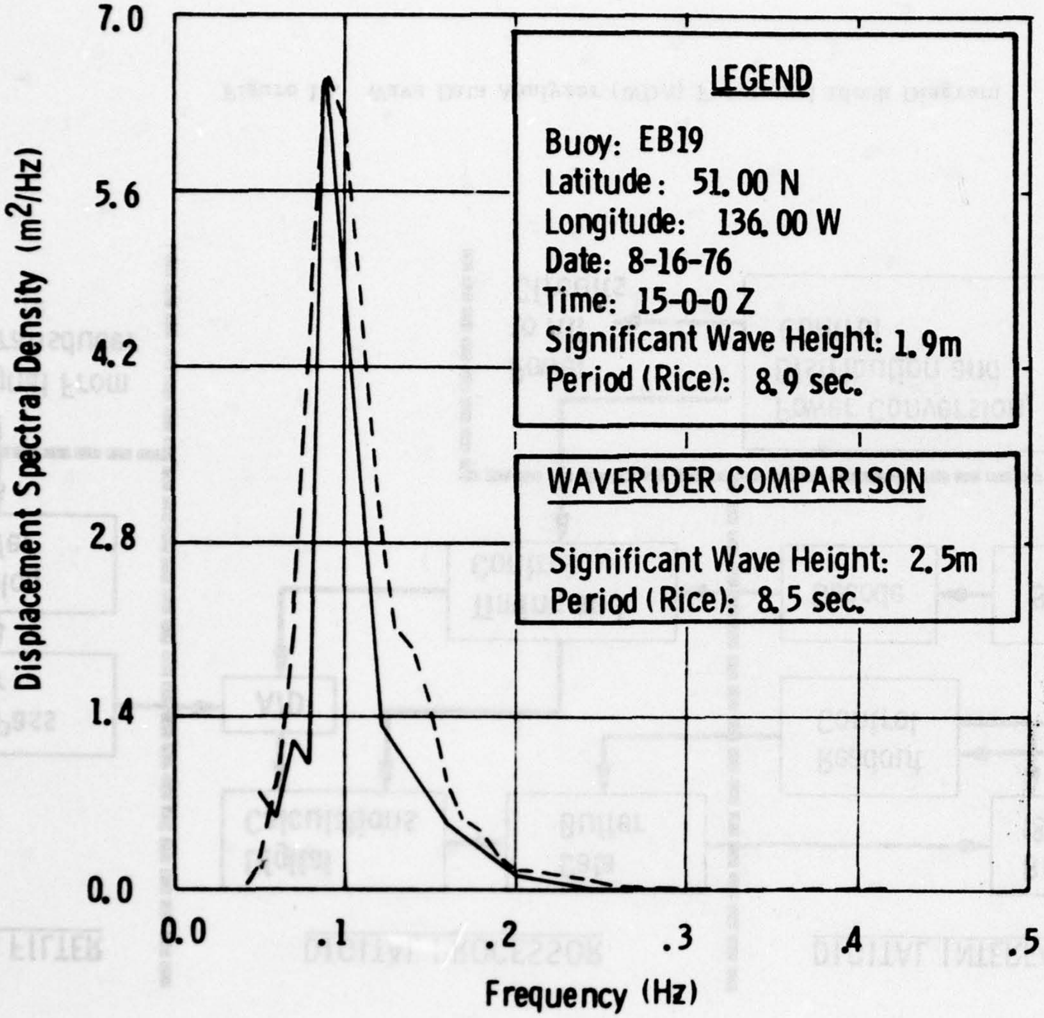


Figure 11. PEB WSA Data Compared to Waverider Data

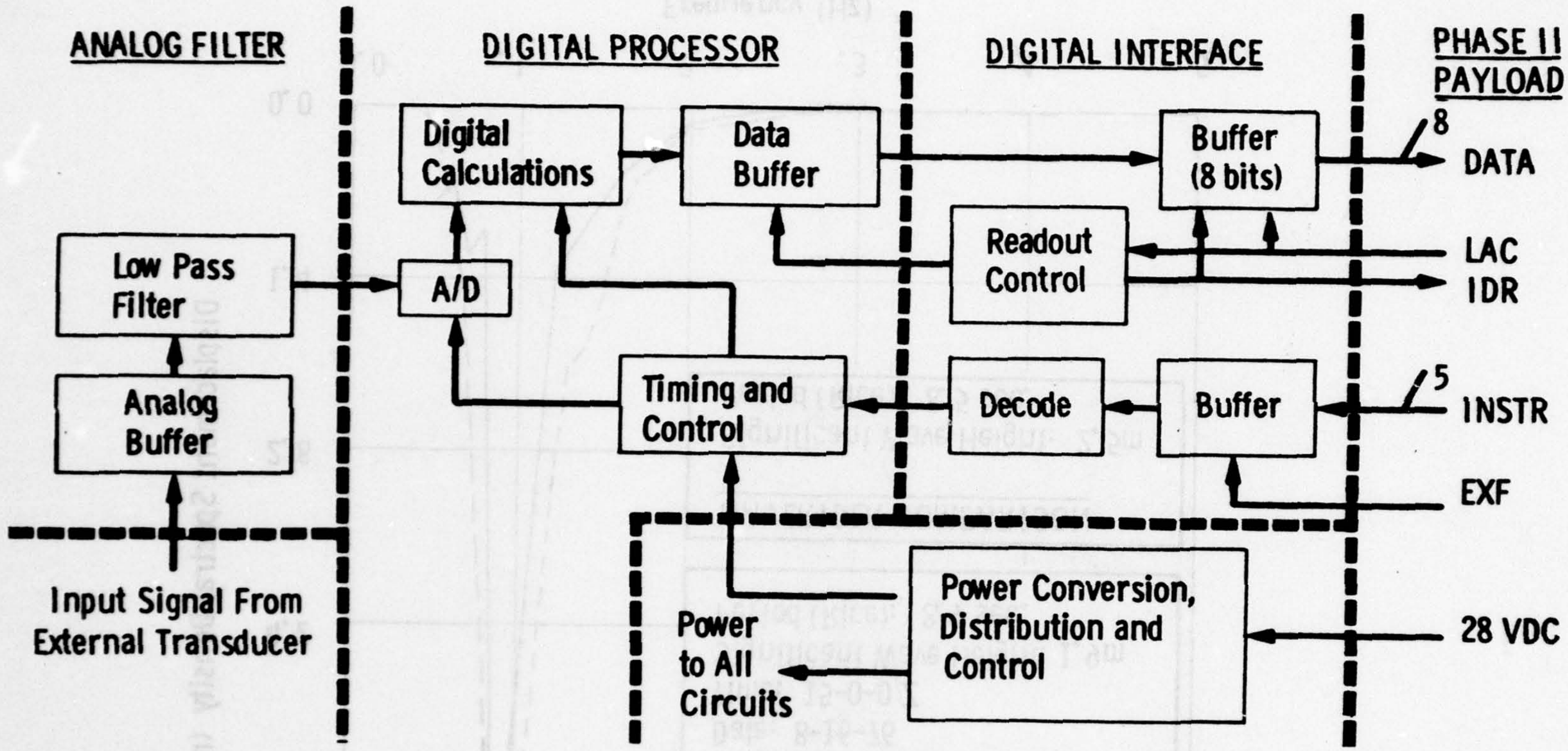


Figure 12. Wave Data Analyzer (WDA) Functional Block Diagram

A/D resolution: 8 bits

Number of lags: 150, 75; 60, 30

Sampling interval: Δt = 2/3 second, = 5/3 second

Duration of sampling: 20 minutes, 15 minutes

Total number of samples: 1800, 540

Output data resolution: zero lag, 30 bits
other lags, 15 bits

Input low pass filter: 6-pole Butterworth with cutoff frequencies of 0.5 Hz, 0.25 Hz

Nyquist frequency: f_N = 0.75 Hz, = 0.30 Hz, = $F_s/2$

Elementary frequency bandwidth: Δf = (0.75/M), = (0.30/M) Hz

Figure 13. Key Parameters

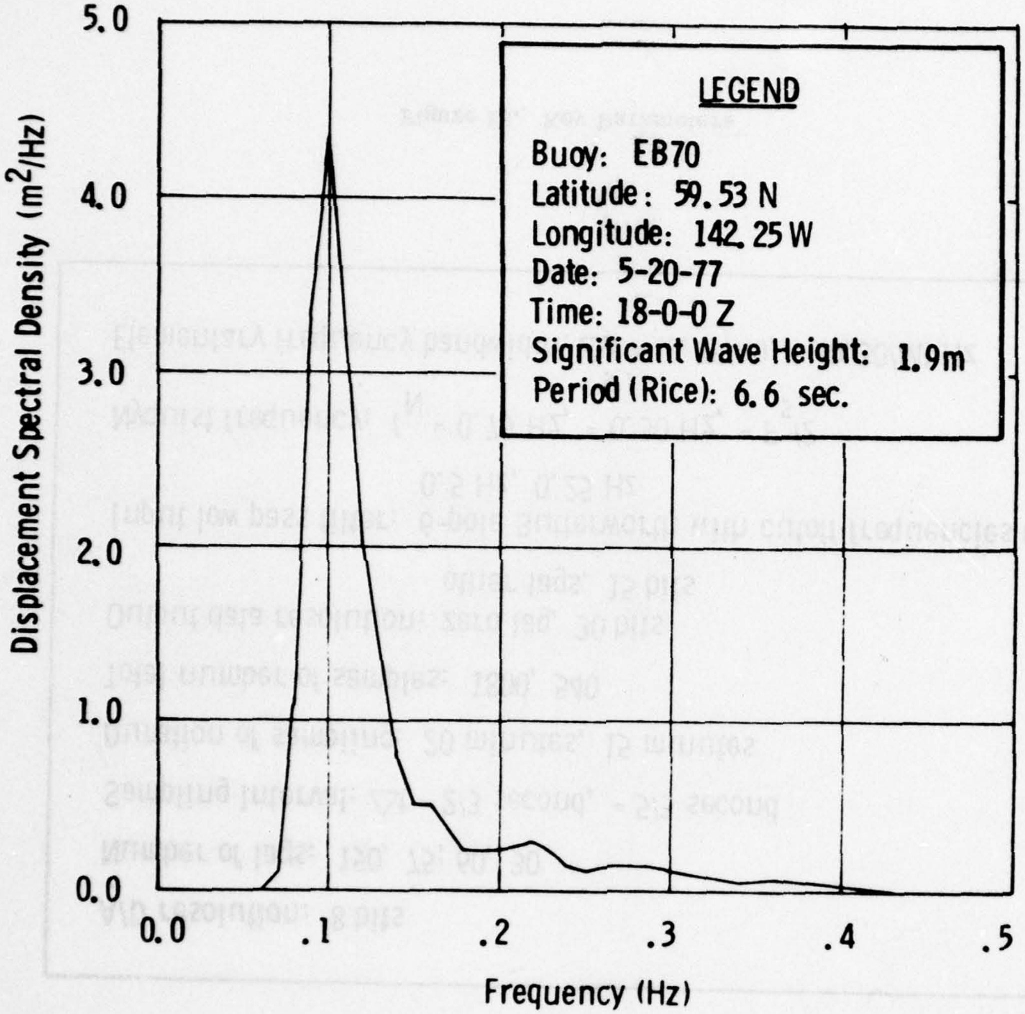


Figure 14. Example of WDA Data, Medium Sea State

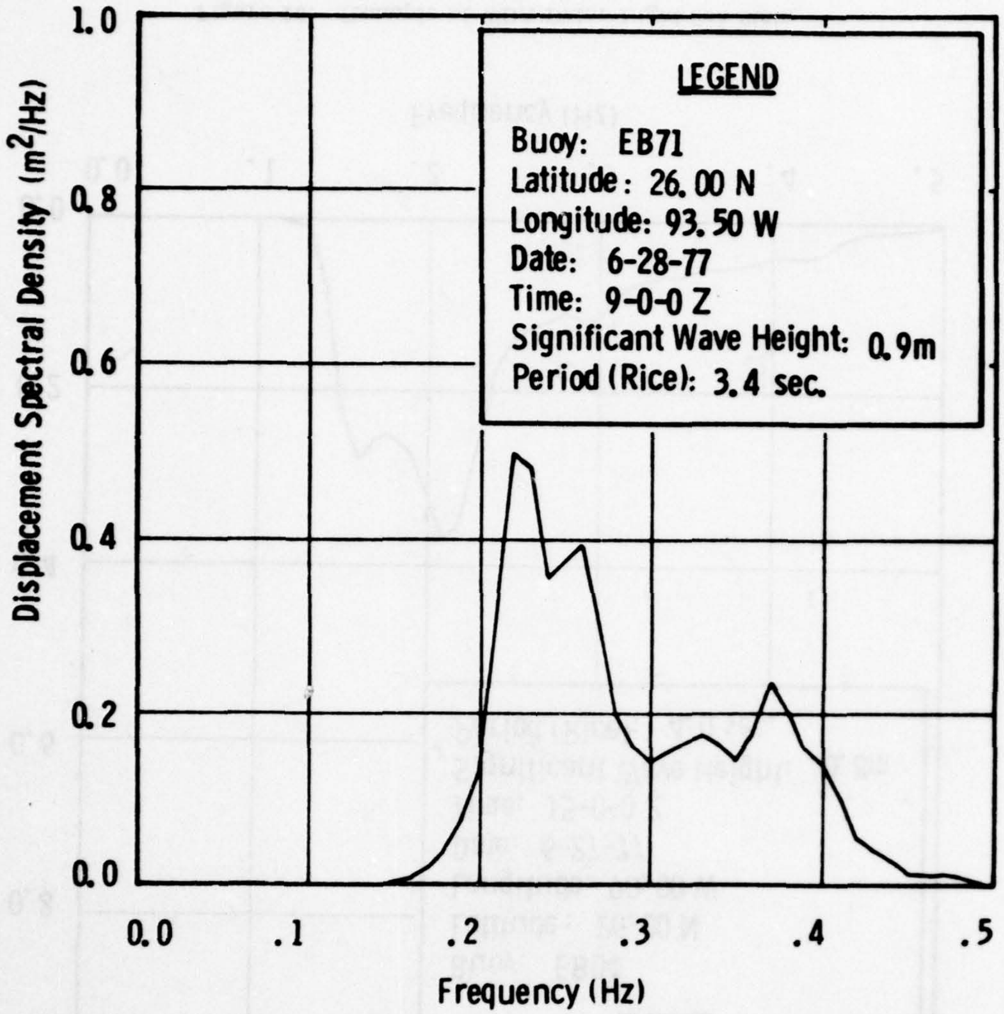


Figure 15. Example of WDA Data, Light Sea State

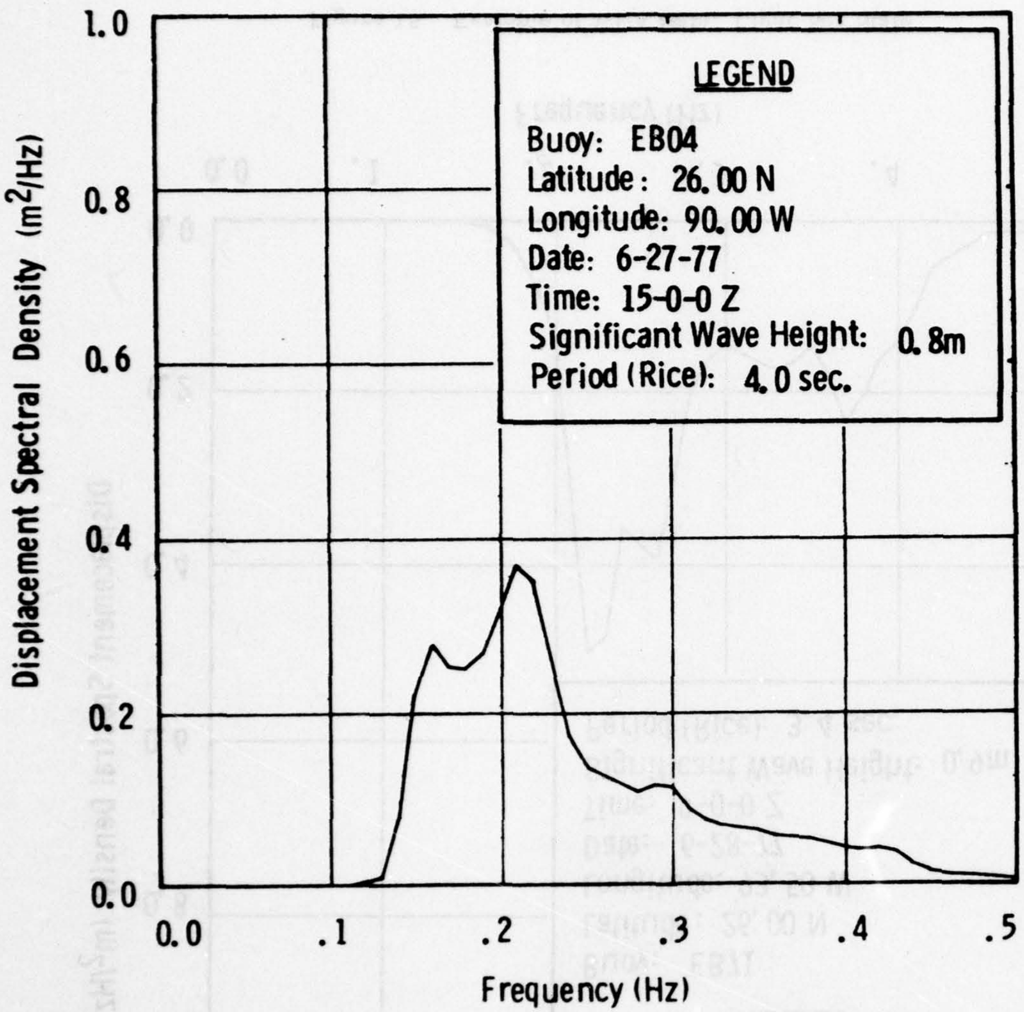


Figure 16. Example of WDA Data, Light Sea State

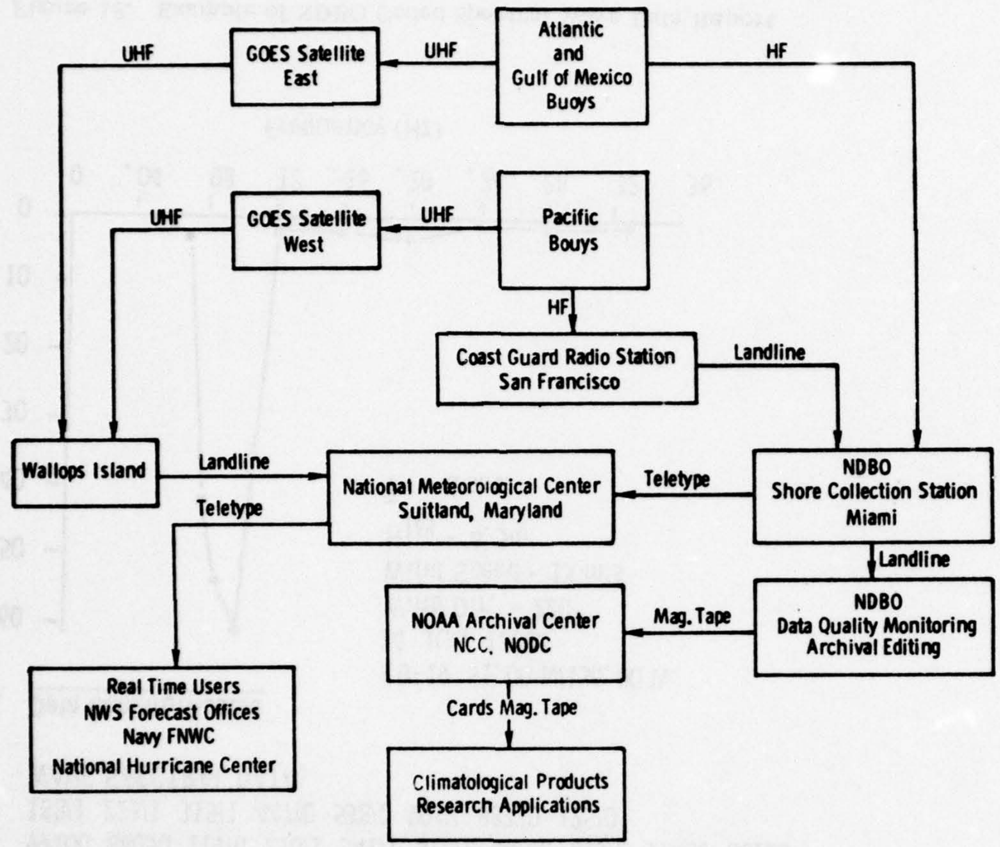


Figure 17. Communication and Dissemination of Buoy Data

I. Sample Coded Message

NNNNAB
ZCZC
SXVD10 PANC 241200
EB19 //510 71360 24121 /2213 30809
99100 88050 119/0 230/1 341/1 426/2 540/2 615/2 99400 88120
188/1 223/1 315/1 447/0 538/0 99/// 88330 125/0
WAVE SPECTRAL DATA;

II. Data Communicated

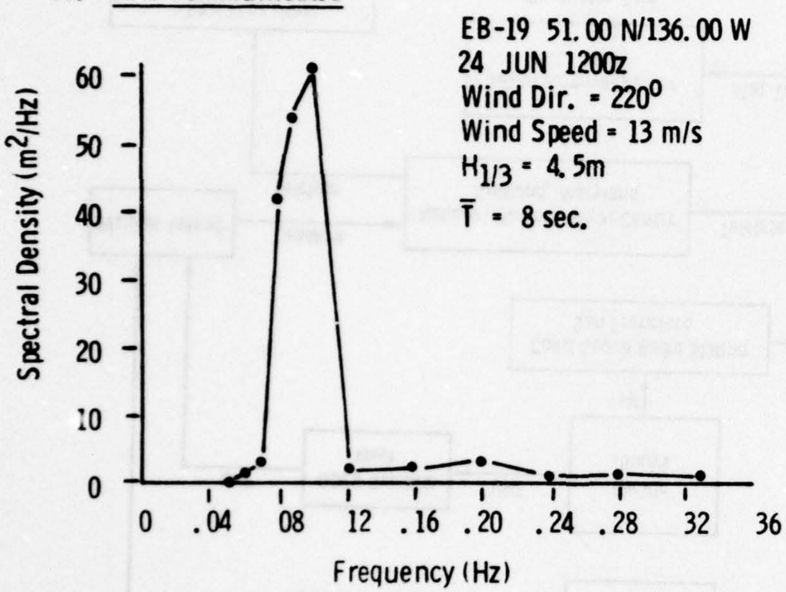


Figure 18. Example of NDBO Coded Spectral Wave Data Report

INCLOSURE 13

DEPARTMENT OF THE ARMY
NORTH PACIFIC DIVISION, CORPS OF ENGINEERS
P.O. BOX 2870
PORTLAND, OREGON 97208

NPDEN-TE

18 October 1977

SUBJECT: California Coastal Data Collection Program - Wave Recording and Analysis Conference

Division Engineer
U. S. Army Engineer Division, South Pacific

1. Reference SPDPD-C letter, subject as above, dated 6 October 1977.

2. I am following your efforts to initiate the California Coastal Data Program closely as we have found that there is a need to better quantify and understand the coastal processes along the Oregon, Washington and Alaska shorelines, and we may wish to undertake a similar program in NPD.

3. We are aware of the lack of standards for recording and analyzing wave data and would like to participate in any coastal wave data meetings that you may schedule in the future, however, due to prior commitments we will not be able to participate in your 26 and 27 October meeting. We view this first attempt at standardization to be of great importance as it will probably establish the boundaries of information that may be obtained by utilizing various recording intervals, times, and sampling frequencies in addition to establishing equipment limitations in obtaining data at what may be the most desirable intervals, times, etc. The standardization of analysis technique could be premature at this time, although a generally acceptable technique with limitations recognized would seem to be in order if raw data is storable so improved methods in analysis can be used when improved methods become available. Due to differing analysis techniques and expected improvements, data recording and storing methods may be more critical than today's analysis.

Wesley E. Peel

WESLEY E. PEEL
Major General, USA
Division Engineer

Incl 13

P 251950Z OCT 77

FM DIVENGR USAEDPO FT SHAFTER HI //PODED-PH//

TO DIVENGR SOPAC SFRAN CA //SPDPD-C/MAGOON/O

BT

UNCLAS

SUBJ: WAVE RECORDING AND ANALYSIS CONFERENCE

A. SPDPD-C LTR, 6 OCT 77, SUBJ: CALIFORNIA COASTAL DATA COLLECTION PROGRAM - WAVE RECORDING AND ANALYSIS CONFERENCE (U)

1. POD UNABLE TO ATTEND COASTAL WAVE DATA MEETING SCHEDULED FOR 26-27 OCT 77. WE CONTINUE TO EXPRESS STRONG INTEREST IN THE OVERALL PROGRAM, AS DISCUSSED WITH MR. MAGOON. POD PROPOSES TO BUDGET FOR A FUTURE PROGRAM SIMILAR TO YOUR EFFORTS ALONG THE CALIFORNIA COAST. REQUEST YOU PROVIDE COPY OF MINUTES OF THE MEETING.

2. POD'S WAVE GAGING PROGRAL HAS BEEN VERY LIMITED. WE RECOGNIZE A DISTINCT NEED TO OBTAIN RELIABLE WAVE INFO TO PROVIDE FOR STABLE AND ECONOMICAL COASTAL IMPROVEMENTS THROUGHOUT THE STATE, MARIANAS, GUAM, AMERICAN SAMOA AND THE TRUST TERRITORIES (FUTURE). HARDWARE, FIELD TECHNIQUES AND DATA PROCESSING AND EVALUATIONS PROCEDURES DEVELOPED BY SPD WILL BE OF IMMEASURABLE VALUE TO POD TO COMPLETE PROGRAM FOR THE PACIFIC AREA.

3. IT IS EXPECTED THAT A COMPLETE PROGRAM FOR THE MID-PACIFIC AREA WOULD BE IN THE ORDER OF $2 MILLION OVER A 3 TO 4 YEAR PERIOD. WE WILL BE CONSULTING WITH YOU TO DEVELOP A TOTAL PROGRAM NEED.

LMVED-WH (SPD 6 Oct 77) 1st Ind
SUBJECT: California Coastal Data Collection Program - Wave Recording and Analysis Conference

DA, Lower Mississippi Valley Division, Corps of Engineers, Vicksburg, Miss. 39180 27 Oct 77

TO: Division Engineer, South Pacific, ATTN: SPDPD-C

1. The only District that has a coastal area within LMVD is New Orleans (NOD) and its problems are significantly different from those in SPD, as discussed in Incl 1. In light of this dissimilarity, I did not feel that it would be to our advantage to send a representative to the 26-27 Oct 77 meeting. However, I would like to receive a copy of the minutes of the meeting and be informed of subsequent coastal meetings, as we may be interested in attending those.

2. With regard to your request in para 2 concerning wave recording intervals, times, and sampling frequencies, we offer the following comments:

a. The wave-recording interval should be continuous over 1 year or more depending upon funding allowances in order that wave height-duration statistical data can be generated in terms of hours per year as presented in Technical Memorandum No. 87 entitled "Wave Statistics for the Gulf of Mexico off Burrwood, Louisiana" by the former Beach Erosion Board. These data are useful to determine probable maintenance requirements for coastal structures such as jetties, groins, or beach nourishment projects.

b. If funds are a limiting factor, then only at certain times may it be possible to make measurements or reduce the data in the office. During the time that the NOD made wave-height and period measurements on Lake Pontchartrain, it became infeasible to reduce all data taken on a continuous basis; therefore, only data for waves 5 feet or higher were processed. Lower waves were of little significance.

c. We recommend that the time and sampling frequency should be at least 2 to 3 minutes once every 15 minutes during storms and 2 minutes once every hour under normal conditions. These values would have to be adjusted based on specific geographical locations along the coastline.

3. The traditional statistics, that is, significant wave height and wave period, should be retained for commonality of engineering use in design of coastal structures.

2 Incl
nc

R. C. MARSHALL
Major General, USA
Division Engineer

INCLOSURE 14

COLLEGE OF ENGINEERING

UNIVERSITY OF FLORIDA

GAINESVILLE, FLORIDA 32611
AREA CODE 904 PHONE 392-1436
WAVE TANK – 392-1051

COASTAL AND OCEANOGRAPHIC
ENGINEERING DEPARTMENT
336 WEIL HALL

October 24, 1977

M E M O R A N D U M

TO: Participants, Coastal Wave Data Meetings, October 26-27, 1977.
U.S. Army Corps of Engineers Division, San Francisco, California.

FROM: Gary Howell, Coastal and Oceanographic Engineering Laboratory

The University of Florida Coastal Data Network is a system of remote, unattended field stations which are linked to a central computer in Gainesville by dial-up telephone lines. The field stations are intended to measure on-shore and nearshore phenomena of interest to coastal engineers and oceanographers. At present these measurements are limited to measurement of the tide and wave-height spectrum in the off-shore area. Figure 1 shows the present and future locations of the stations. The Marineland, Cape Kennedy, and Miami stations are currently operational. The Clearwater station is the next to be installed, and will be the first to give directional spectra. Upgrading of the other stations to directional as well as adding other measurements such as bottom currents and temperature is anticipated.

The field station is made up of an underwater package, a shore cable, and a shore station. The underwater package is a self-contained microcomputer system capable of digitizing up to eight channels of data. The microcomputer according to its program may act on or respond to commands from shore and write data on its own internal digital cassette or send data to shore. Presently, it is programmed to operate in two modes.

1) The field station mode sends data from one or more transducers to shore on command from the shore. In practice this command may be received over the telephone lines from the central computer or be generated by the shore station. This is the normal mode for acquiring ambient data.

2) The storm mode is entered after command from the shore. Once entered the package will automatically record a 17-minute data record once per hour for 6 days. After storm mode has been entered the package will continue to operate, even if the shore station and/or cable are destroyed.

The system design of the field station has made an effort to use standard hardware interfaces where ever possible. A summary of the hardware interfaces of the system is shown in Figure 2. Non-standard interfaces are noted as well as applicable standards where they occur. It should be noted that the use of standard interfaces has paid off in a variety of areas. Most notably are the use of competitive "off-the-shelf" data communications hardware as opposed to special designs, ease of maintenance, and flexibility in matching cost-performance of hardware.

Since the interface with the underwater package is a standard computer interface, the shore station can be anything from another computer to a standard modem. The present shore stations called Real Time Shore Stations are specially packaged commercial modems. They allow data to be taken in Gainesville in real-time, i.e., a twenty-minute record requires a twenty-minute phone call. Under development at this time are Buffered Data Shore Stations which are sophisticated microcomputer systems containing a half mega-byte of disc storage. These systems will take data automatically on a schedule provided

by the central computer. They will store the data internally until called by the central computer and then dump it back at high speed. These systems will allow an improvement in telephone costs as well as providing more frequent records and simultaniety between field stations.

The data format of the storm mode is the result of trade-offs between spectrum stability, resolution, recording interval, and total length of recording time. For the case of hurricanes more frequent spectra are desirable than during ambient conditions. The main limitation is the finite amount of data which can be stored on one cassette.

The sampling and analysis parameters presently used for storm mode are:

F_s = 1 Hz - Sample frequency

T_r = 1020 sec. - Record length

T_I = 1 hour - Inter record interval

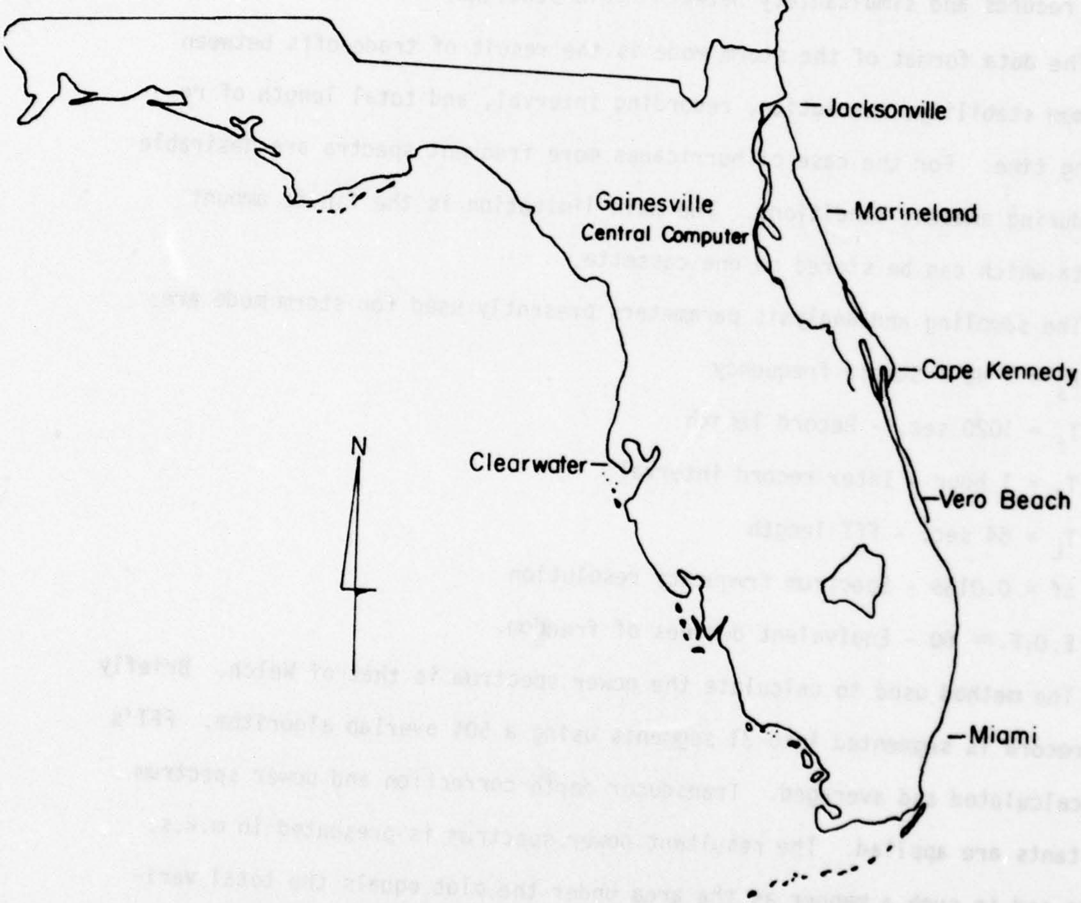
T_L = 64 sec. - FFT length

Δf = 0.0156 - Spectrum frequency resolution

E.D.F. $\approx$ 60 - Equivalent degrees of freedom.

The method used to calculate the power spectrum is that of Welch. Briefly the record is segmented into 31 segments using a 50% overlap algorithm. FFT's are calculated and averaged. Transducer depth correction and power spectrum constants are applied. The resultant power spectrum is presented in m.k.s. units and in such a manner as the area under the plot equals the total variance. Three examples of power spectrums are shown in Fig. 3, 4, and 5. These were produced by the Marineland underwater package in storm mode on January 6, 1977.

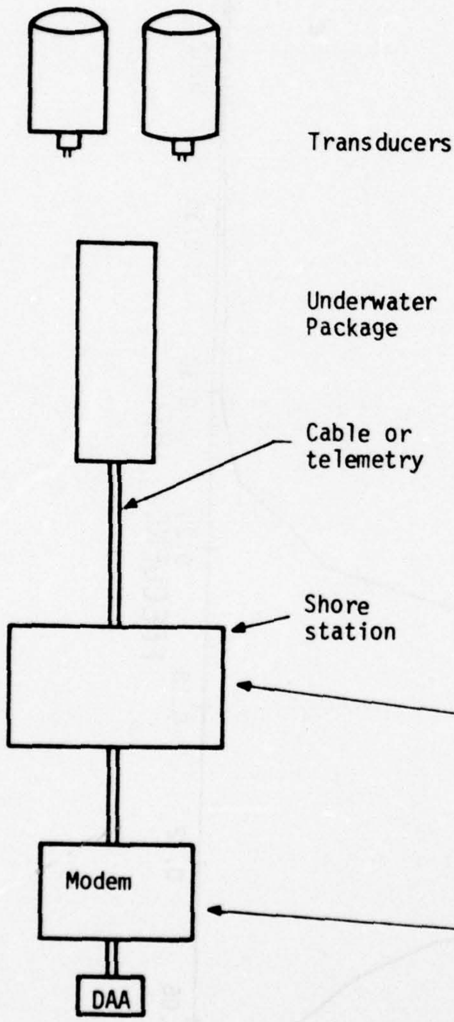
GH/cjp



UNIVERSITY OF FLORIDA COASTAL DATA NETWORK

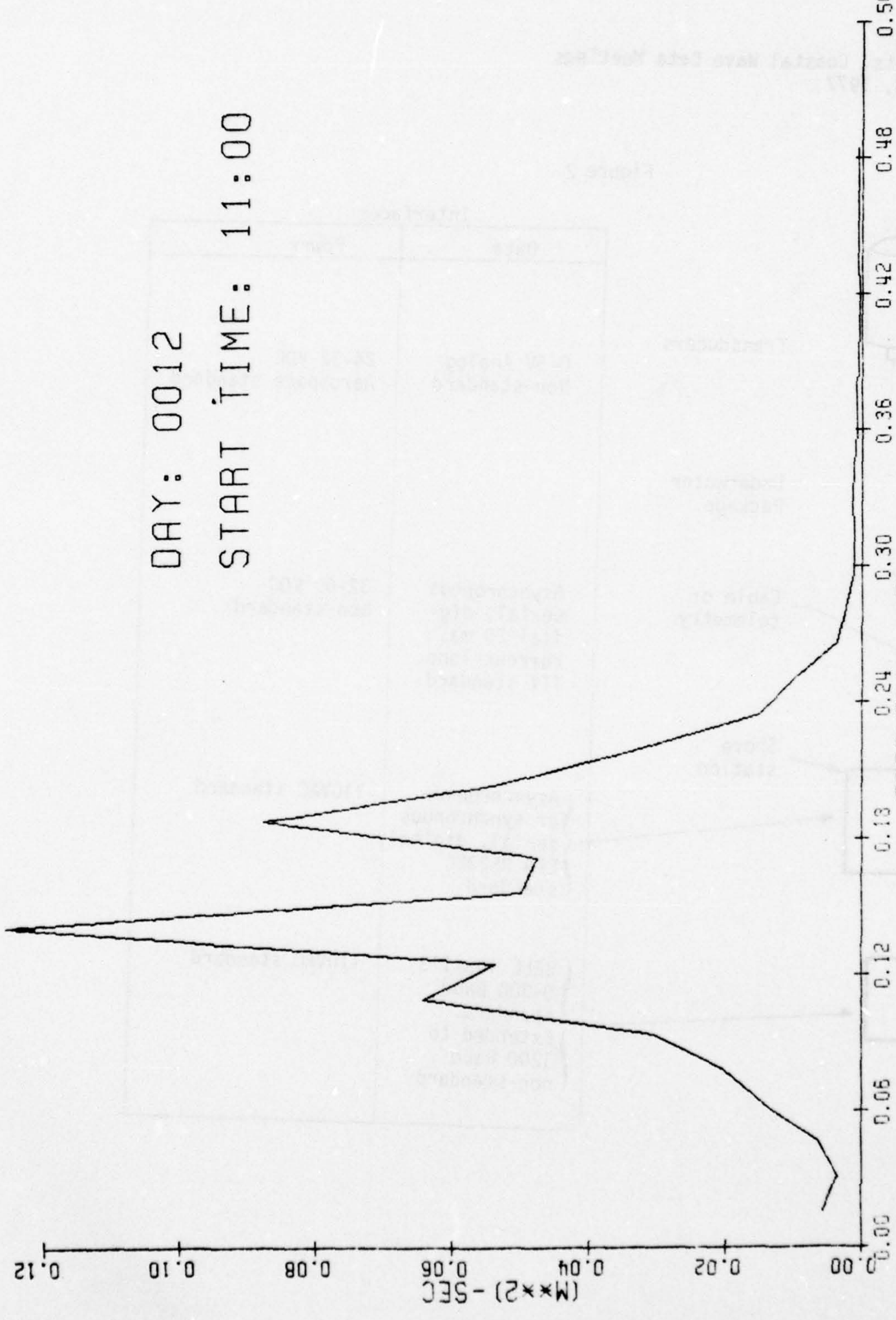
Figure 1

Figure 2



Interfaces

Data	Power
0-5V Analog Non-standard	24-32 VDC Aerospace standard
Asynchronous serial, digital 20 ma. current loop. TTY standard.	32-60 VDC Non-standard
Asynchronous or synchronous serial, digital EIA RS232C standard	110VAC standard
BELL 103/113 0-300 Baud standard. Extended to 1200 Baud non-standard.	110VAC standard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START TIME: 11:00
FREQUENCY (HZ)
(M**2)-SEC
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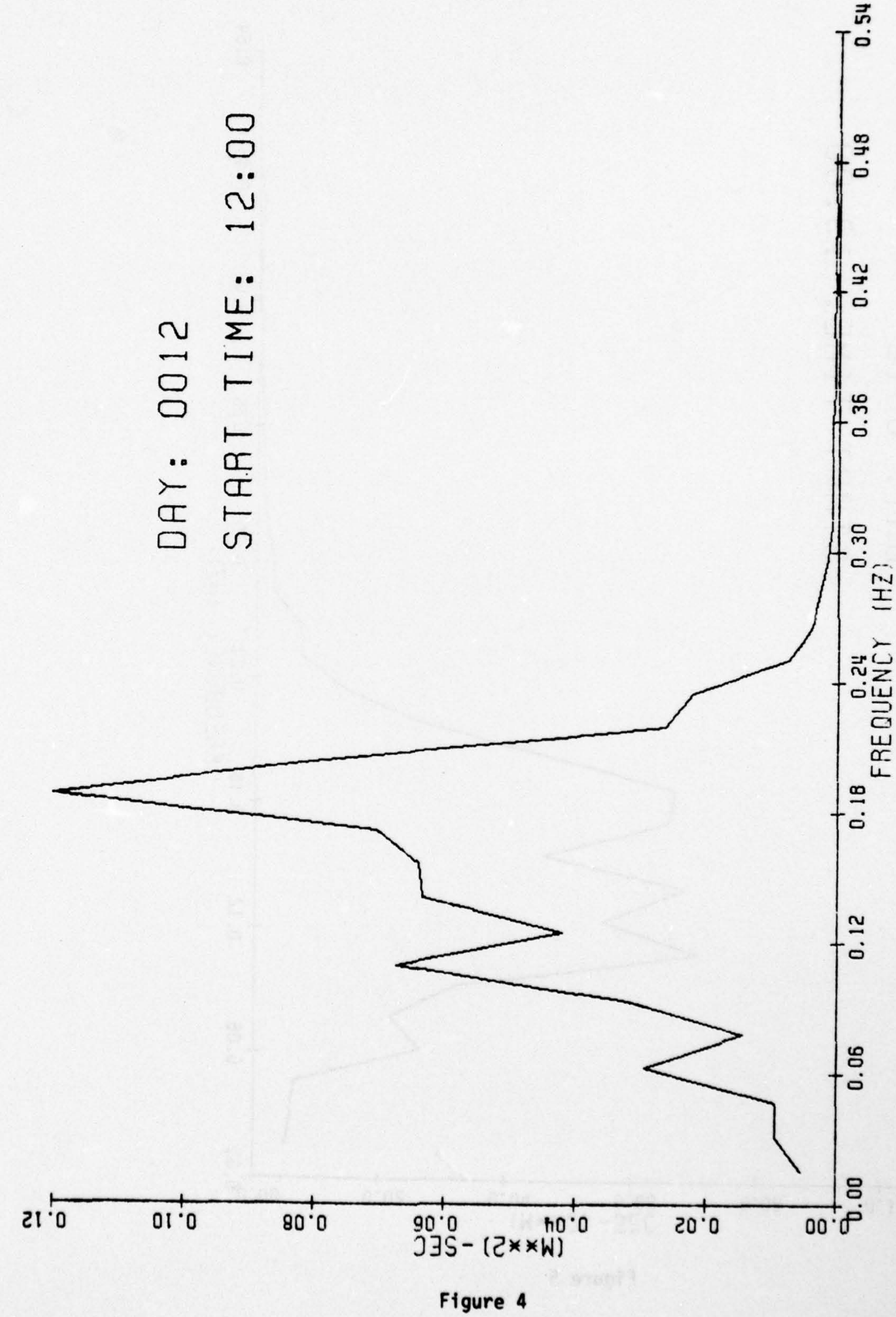
0.02
0.04
0.06
0.08
0.10
0.12
0.06
0.12
0.18
0.24
0.30
0.36
0.42
0.48
0.54

Figure 3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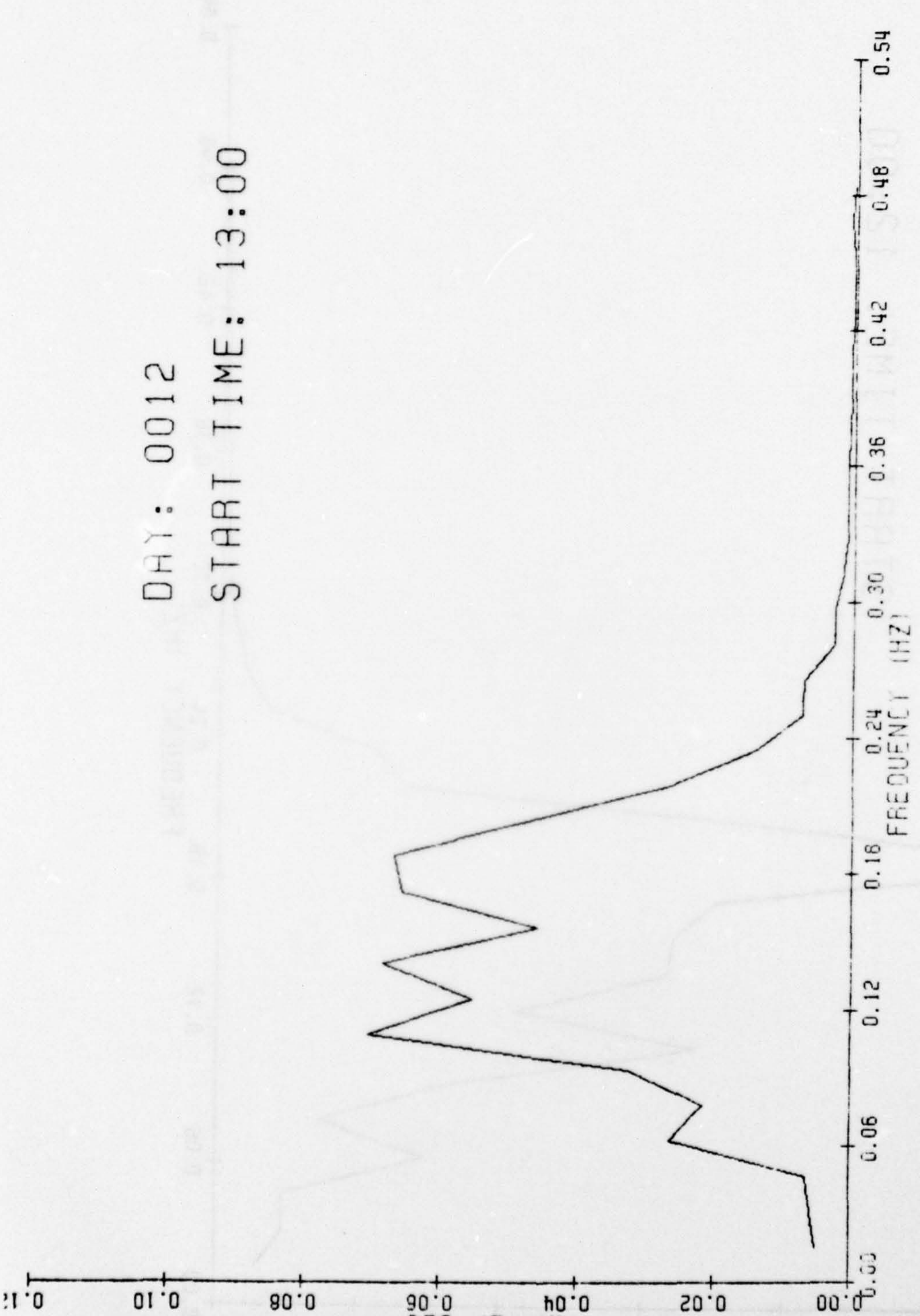
0.06
0.12
0.18
0.24
0.30
0.36
0.42
0.48
0.54
0.00
0.02
0.04
0.06
0.08
0.10
0.12

Figure 4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0.06
0.12
0.18
0.24
0.30
0.36
0.42
0.48
0.54
0.02
0.04
0.06
0.08
0.10
0.12

Figure 5

INCLOSURE 15

ASCE COMMITTEE ON WAVE STATISTICS PRESENTATION

BY ORVILLE T. MAGOON (SPDPD-C)

Mr. Orville Magoon reported briefly on the expected output of the American Society of Civil Engineers Task Committee on Ocean Wave Statistics which he chairs. He indicated that his committee is preparing a standard practice manual on wave record analysis. This manual is scheduled to be in draft form in mid-1978 and should be available in printed form by ASCE in early 1979. Upon completion of the committee draft of the wave record analysis report, the committee will prepare a second volume on ocean wave analysis programs of use in Automatic Data Processing. Mr. Magoon also indicated a concern for wave groups by the ASCE waves committee. Comments of Dr. Muga, Duke University in this regard are inclosed.

1 Incl
as

Duke University • School of Engineering
DEPARTMENT OF CIVIL ENGINEERING
Durham, North Carolina 27706 Tel. (919) 684-2434
October 14, 1977

Dr. Orville Magoon
Department of the Army
Pacific Division
Corps of Engineers
630 Sansome Street, Room 1216
San Francisco, California 94111

Dear Orville:

Thanks for the copy of the contract that you have with Professor Thompson (through DNOD). I am delighted to see that this is being undertaken and hope to follow this work closely.

With reference to measurements in the offshore environment, I gather that the surface water fluctuations will be measured by a single wave rider bouy. Some of the measurements from the North Sea, (made by Exxon Production Research Company), that I have been analyzing were obtained from a wave rider bouy. Although we are completely satisfied with the short period measurements (events in the usual period band of wind generated waves), we are having some second thoughts about the longer period events, specifically wave grouping. The indirect evidence for wave grouping is clear but the direct evidence of wave grouping causes and effects is not so clear. Some of our very careful spectral analysis show some power down in the wave grouping frequency, but we question whether this might not be an artifact resulting from the low frequency cut off of the bouy sensors and/or the bouy mooring response and/or the statistical averaging (including updating of the mean zero level) which was built into the logic of the instrumentation package.

We hope to shed more light on this question when we analyze the Hurricane Camille records later next year. These records were collected from a fixed wave staff rather than a bouy.

The above comments are for information only, but please feel free to circulate them as you please.

On another matter, I have enjoyed immensely serving with you on the executive committee of the WWPCO Division. You are certainly going to be missed. I hope that ASCE will continue to benefit from your very active participation. The Division is indebted to you beyond measure.

Dr. Orville Magoon
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October 14, 1977

If there is any way in which I can assist you in your work, please do not hesitate to call on me.

Very truly yours,

Bruce J. Muga

Bruce J. Muga
Professor and Chairman

BJM:mh

INCLOSURE 16

CALIFORNIA DATA COLLECTION PROGRAM

Work Group Recommendations
for
Sampling

Sampling Rate Standard

The preferred standard is 4 Hz. The acceptable alternate rates are:

a. 1 Hz
b. 2 Hz

Record Length Standard

The preferred standard length is 1024 seconds. The acceptable alternate length are:

a. 2048 seconds
b. 512 seconds
c. 4096 seconds

Resolution Standard

The preferred minimum resolution for the zero mean signal representing surface elevation is one part in 2^{10} of the full range of variability.

Observational Frequency Standard

1. The preferred standard frequency of observation for intelligent systems that can adjust automatically observational frequency in response to local conditions is once each six hours.

2. The preferred standard for systems with fixed frequencies is once each three hours.

3. For variable frequency systems, sampling every hour during extreme events is the preferred standard.

4. The recommended procedure is to measure as closely as possible in synchrony with WMO synoptic observations intervals.

Standards for Units

1. For raw data records the standard units are:

a. Centimeter (cm) for height
b. Hertz (Hz) for frequency

2. This standard does not restrict the choice of units for analysis purposes.

INCLOSURE 17

CALIFORNIA DATA COLLECTION PROGRAM

Work Group Recommendations
for
Standardizing Raw Data Format

1. During the working session of the South Pacific Division's Coastal Wave Data Meeting, a work group was organized to consider standardization requirements for storing and archiving raw wave data which were assumed to be time-series representations of water surface elevations. This group was specifically charged with the responsibility of providing general recommendations as to storage media, format structure, and archiving techniques.

2. A summary of recommendations from this group follows:

<u>a.</u> Magnetic tape is the required medium for storage of raw wave data as well as any results of analyses. Preferred tape density and number of tracks are 800 BPI and 9 tracks.

<u>b.</u> Digital representation of raw wave data to be recorded on magnetic tape is 12-bit integer binary including sign. The number of bits/data word is based upon set of recommendations from analyses work group. The bit structure of data words on 9-track tape assuming the magnetic tapes are created at field installations by a 16-bit-word minicomputer should be 16-bit words each containing 12 bits of data with the 4 most significant bits filled with zeros. However, for archiving these data, additional considerations should be given to packing these data in an efficient manner such as 1 1/3 12-bit data words in each 16-bit word on tape, etc.

<u>c.</u> Specific tape formats for raw wave data are difficult to establish

at this time. However, certain guidelines can be set forth. For the original data tapes from Corps' field installations unlabeled files should be created. Each file on tape should contain all wave information collected during one 17 minute sample period for all stations and gages reporting to a given regional installation. Each file should contain a fixed length file header with field installation identification, time, and other appropriate information to determine number and length of data records in each file. Each data record should contain all wave information for one gage with data records created sequentially according to station numbers and gage numbers. Each data record should contain a record header with time and date of observation, station and gage identification, calibration of transducer, reference datum, sampling interval, and any other pertinent information. A preliminary concept of one possible tape format is proposed in Incl 1.

d. Each original magnetic tape should be supplemented with written documentation such as log sheets, tape dumps, and other archiving requirements. Standard forms for such information should be developed. Submission of such forms should be mandatory and required at time of submitting original data tapes for permanent storage and archiving by Corps.

e. In terms of future usage of these data, studies should be conducted as to efficient storage and/or packing techniques of raw data for archiving, conversion methods to create tapes compatiable with other users' computer facilities, and information dissemination requirements for Corps users as well as other users.

PRELIMINIARY TAPE FORMAT

File Structure:

File I.D.	*	••• Data Records •••	*	EOF	*	*

File I.D. Record -- Fixed Length

Field Installation Code
Year
Day
Hour } GMT of 1st Data Record
Minute
Second
Total No. of Data Records per File
Data Record I.D. Length
Binary Exponent (N) for No. (2^N) of Data Words in Data Record

Record Structure: One record/gage grouped by station

Record ID	Data (2^N Words)	*	Record I.D.	Data (2^N Words)

Record I.D.
Year
Day
Hour } GMT of Data Observation
Minute
Second
Station No.
Gage No.
Calibration Coefficients
(a) slope
(b) offset
Reference Datum (Elev. off bottom)
Sample Interval

Incl. #1

INCLOSURE 18

CALIFORNIA DATA COLLECTION PROGRAM

Governing Philosophy for Wave Measurements
Work Group Recommendations

The following basic principles were agreed upon (by the working group established to document an overall philosphy for the California Data Collection Program) to guide the planning and execution of this important and far-reaching program.

1. Wave data should be recorded in a form acceptable to the principal users.

2. The wave recording system should be flexible enough to insure data acquisition from all important synoptic and irregular events.

3. All available information (forecasts, predictions, warnings, etc.) should be used as an integral part of the program plan to insure that significant events (tsunamis, tropical storms, Santana's etc.) are anticipated and recorded.

4. All data should be recorded at synoptic intervals corresponding to standard meterologic observation times to insure the capability to cross-correlate with various kinds of other data.

5. The wave recording system should be designed so that waves are automatically recorded once they reach some predetermined elevation or energy level.

6. At least some of the system (2 to 4 gages) should be operated (continuously) to insure that data are recorded on all events of interest.

7. A strong quality control effort is necessary for all system components to insure that the wave data are recorded properly.

8. Systematic and periodic checks (including calibration) of the accuracy of wave recordings (elevation and time) is essential to insure maximum future use of the data.

9. Detailed information and documentation nomenclature should be included on the tape format to insure that future users have all necessary knowledge to make maximum use of these data.

10. The wave measurement system should be designed to minimize trips to the field for maintenance (in the interest of minimizing total cost).

11. Documentation of all system components, hardware filtering, accuracy and calibration of the system, tape formats, sampling, editing routines, software and analysis programs should be provided in manual

form and all modifications thereto should be recorded as a manual update (including time of installation and data affected by the change).

12. Portions of the system should be installed at locations to provide data for verifying certain phenomena associated with wave forecasting/hindcasting (i.e. island sheltering and nearshore wave transformations).